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UNIVERSITY OF ALBERTA

GIFTED STUDENTS SOLVING REAL WORLD PROBLEMS

BY

JOANNE MARGARET CAMERON

A thesis submitted to the Faculty of Graduate Studies and Research in partial fulfillment of the requirements for the degree of

MASTER OF EDUCATION

DEPARTMENT OF ELEMENTARY EDUCATION

EDMONTON, ALBERTA

Spring, 1993

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled

GIFTED STUDENTS SOLVING REAL WORLD PROBLEMS

submitted by Joanne Margaret Cameron in partial fulfillment of the requirements for the degree of MASTER OF EDUCATION.

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Date April 8 1993

Abstract

Despite the plethora of practice problem solving tasks done during coursework, students are leaving classrooms unable to solve *real life* problems. Problem solving process training seems to be insufficient for many individuals, partly because the well-structured problems presented to them in schools differ from the ill-structured problems they will be facing as they leave the building. Students need practice with ill-structured problems if they are to develop the expertise they require.

This study was a wholistic description of the problem-solving process exhibited by high ability, middle-school students. The students were asked to design their own market research investigations to test the claims made by a commercially available boardgame's architect, that his product, the game of "FFlow", "turns on creativity". Exploratory research methods were used to observe a group of five, ninth-grade Academic Challenge students who volunteered to conduct the six-week project in lieu of a regular language arts assignment. Two students chose to work individually, and the other three worked together as a team. The researcher functioned as a participant observer while the students defined and solved problems stemming from their research. The students were designing their own solutions to ill-structured problems, with the researcher facilitating their work through coaching, rather than direct teaching of research skills.

Findings indicated that, although the students were grouped homogeneously for programming, their experiences with the challenges posed by the project differed dramatically, whether in their individual approaches to the research project itself, or in the recognition and solving of the problems stemming from the task. Though the researcher observed similar phases to the students' problem solving process, there were significant differences in methodologies and products presented. The students each progressed at different rates, and even repeated steps, depending upon the context they both perceived and created. This resulted in variations of how, and what they defined as, problems.

A model consisting of five composite factors interacting with problem solving was synthesized from the themes emerging from the data and the constructs from the literature. The model formed the basis for comparison of the students' problem solving processes. Two of these composites were found to have the most significant effect on performance: the students' *attitude* and perception of *support*. These were seen to influence the other three composites: recognition and definition of *problems*, use of *past experience* and responses to *environment*.

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Interaction of Composites and Their Influence upon Problem Solving

CHAPTER ONE
INTRODUCTION

This study was developed to gain a deeper understanding of the problem solving process exhibited by high-ability, middle-school students as they structured a market research project. It was prompted by the researcher's concern that students are not always adept at solving their own problems and her desire to help them to help themselves. There is abundant literature on problem solving, but there have been few studies to date on gifted students engaged in problem solving, and fewer still about students using a process to solve problems, other than those preselected problems through which they are guided by teachers. There is relatively little data on real world problem solving by any group of students. The researcher wanted to examine more closely the process employed by students actually working on a problem of their own definition and formulation, one that more closely emulates what Renzulli (1977) terms a *real problem*.

Years ago, S. N. Kaplan (personal communication[1], 1983) shared the story of a little girl who surpassed her peers in creative problem solving class. One afternoon, Dr. Kaplan happened upon the prize pupil just outside the school. The puzzle whiz was sitting, crying on the curb. Naturally, Dr. Kaplan inquired why the child had not gone home, since it was getting late. The wailing and sobbing increased, "I can't go home! The crossing guard has gone and I'm not allowed to cross the streets by myself!"

This top student's inability to deal effectively with a real concern negated all the gold stars in her problem solving exercise book. Parnes suggested, "creativity at its simplest level . . . [is] combining what we know in new ways to solve a problem that may affect us individually." (Parnes, 1981, p.57)

The impetus for this undertaking stemmed from many years of working with children. It always puzzled the researcher why some students could perform adequately on

[1] Personal communication refers to conversations held with the individual cited.

assignments and would fail miserably at recess, while others bombed tests but led peers on the playing fields. Guilford's (1966) structure of the intellect, Sternberg's (1984) triarchic theory of intelligence and Gardner's (1985) work on multiple intelligences began to offer some reasons behind and support for these observations since they validated different types of intelligence operating behind human functioning.

Further work on management training (Blanchard & Johnson, 1981) and learning styles (Dunn, Dunn & Treffinger, 1992; Gregoric, 1980; McCarthy, 1980; Meisgeier, Murphy, & Meisgeier, 1989) offered limited success at addressing these issues during classroom activities. Still there seemed more to the problem. Self-esteem always seemed to be a hub upon which human potential functioned; yet it too, was not the final complement to the puzzle. Studies of brain research, (Sylwester, 1990) societal pressure and family backgrounds also shed some light on the issue. The bottom line was still the dynamic interaction of contributions from all of the above coupled with the guidance of the teacher, within the bureaucracy of the school as one institution which seemed to make the variables react.

Although it appeared the researcher was ironically searching for a panacea, with full knowledge that none existed, the pursuit itself seemed the most effective route to improvement of the situation at hand. It seemed that the proverbial reach should exceed the professional grasp. In an effort to control as many of the facets as were within the parameters open to teacher influence, the researcher was in constant search of a catalyst for the process. Problem solving seemed to offer the possibility of becoming that catalyst. However, creative problem solving process training (Eberle, & Stanish, 1980; Isaksen & Treffinger, 1985; Mulcahy, Marfo, & Andrews, 1987; Parnes, 1981) seemed to be falling short of the long-term goal of useful transfer of skills-teaching to actual application to real world problems.

Sternberg (1985b) addressed the issue of real world problems and compared them with the types of problems presented to students during thinking process training. He stated that the

types of problems used to train students differed in many important ways from the real world problems they encounter, and so would naturally have implications for the transferability of process skills. It was this potential warp between the problem and the solution that interested the researcher.

Sternberg (1985b) cautioned that real world problems are often messy, ill-structured, persistent and have consequences that matter. They are not obvious and their solution depends on, and is affected by, context and definition. School problems by contrast, are often predictable, follow a familiar pattern and generally have just one right answer. Students seem to prefer these types of problems for curriculum, because they are easy to get right on tests counting for marks.

Stacy Keach narrated a science-based film series, Search for Solutions, in which he offered, "Models are a rehearsal for reality" (Phillips Petroleum Company, 1977a). The film suggested that models provide a safe medium to explore strategies for use on a more global scale. It was the opinion of this researcher that schools should model society. They should avoid creating an environment which is separate and artificial by rigorously monitoring how they utilize modelling with children. It seemed logical to this researcher that schools should carefully and effectively establish situations where students might model problem solving behavior, and thus prepare themselves for other problems which life might present.

The concept of modelling is inherently neutral, but how it is used dictates its degree and kind of impact. Impact can be positive, evoking a powerful emotional response or negative, touching a child's life superficially. Effective models can draw a child into learning situations the way a good fantasy draws the reader into the story. Disbelief is temporarily suspended and for a while, the child is part of the scenario. At its worst, modelling can be so contrived that the child does not see any point to the exercise. When it does not matter to the learner that the model exists, it ceases to have a positive impact.

Often life outside of school is termed, *the real world,* and much talk centers around how students will cope when they leave school and enter the real world. It is the opinion of this researcher that the students enter the real world when they are born, and it is the school's responsibility to facilitate the students' abilities to meet the challenges posed by their real world.

Sometimes, for some very valid reasons, schools are accused of creating environments which do not model the real world. More than just a few children come to school to escape the severe problems of their young lives. Abuse, poverty, ignorance and parental frustration may inhibit children's abilities to entertain themselves intellectually. School may represent a sanctuary from the challenges of the home. But the gap between school and home needs to be cautiously crossed if the students are to make use of the wonderful opportunities education and schooling may present. Students from disadvantaged environments greatly need to learn coping strategies. These young people are possibly without healthy parental modelling, and might not be receiving adequate guidance for problem solving in their home environments.

The researcher believes that problem solving process training strategies must be flexible enough to be applied to the complex problems which already face the student. Schools should represent a forum in which trained, objective individuals may offer effective guidance. Curricular content should lead to and foster the use of skills in meaningful contexts. Students are not likely to encounter preprinted problems in life. So Sternberg's (1985b) concern for the inadequate transfer of process skills training to real world problems reflected the need for a more carefully crafted transition between the two.

This topic seemed of vital importance because real life problems are faced by students every day. Because problems become steadily more complex as students age it is of specific concern how problem solving abilities mature.

It has long been this researcher's belief that it is through the interaction of context, curriculum and students that learning occurs. Hence the search for solutions to problems of strategy transfer becomes: *How to establish short-term lessons which lead to a long-term outcome of balanced, highly intellectually functioning adults graduating from a school system designed to prepare them for the challenges they may face in an uncertain future?*

More and more writers, journalists, businessmen and songwriters suggest schools need to teach students how to be successful within a changing society while at the same time, being literate and leading fulfilling lives. They do not, however, offer concrete suggestions as to how today's teachers could go about accomplishing this laudable goal in *Ten-easy-steps* between A and B (Sternberg, 1984). One of the problems this researcher observed in the presence of other teachers was that the more abstract the goal, the more difficult and unclear the route to its attainment. Sternberg (1985b) reinforced how society is duped into expecting simplistic answers to complex questions. This he attributed to the romanticized view of problem solving perpetuated by simplistic problem solving training.

It appears that student perceptions of reality are sometimes misconstrued. It is the suspicion of this researcher that students might be misinterpreting what constitutes *real* because the concepts presented through some school-based activities are often cloaked in artificial or over-simplified content. For example, science may come to be seen as a process of manipulating previously laid out materials to prove an existing theory. Demonstrating a predetermined answer to a question is counter to the principle of scientific investigation.

If, for twelve impressionable years, answers are expected to be *right* and are generally obvious from the material presented to students, through carefully prepared information packages, students may logically expect life's problems to be similar. The misconceptions with which students leave school are considered to be detrimental to developing the actual abilities they need. In order to face and conquer real world problems students need

guidance, not pat answers. Miscue analysis and over-generalization are perhaps some of the factors at the root of the gap between process and student production. Students also need the temporary security provided by the solving of manageable problems before they are ready to plunge into the more complex problems facing society.

A real world problem is defined by Sternberg (1985b) as one which needs to be recognized, defined, structured and solved by an individual or group acting within a specific context. It has consequences that matter and does not necessarily have a clear-cut path to solution. He contrasted the principle of real problems with the artificial nature of those problems usually presented to students in school. Real problems are encountered, often messy and persistent. Solving them can be difficult, situation-specific and context-dependent. In schools, problems are often neatly packaged with a predetermined right answer usually readily solvable within a given time frame. There are, of course, some similarities between problems which are contrived and those which emerge or even erupt. They can both be challenging, frustrating, require differentiated approach strategies and may be recognized again when a similar structure is presented.

Often contrived problems are labelled, "Sample problems". The title is fitting. In the business world a sample gives a summative, condensed view of a larger product. Carpet, paint, or product samples offer consumers a manageable portion, representative of the whole product. Customers are then expected to visualize the larger product and decide if it meets their needs.

In school, sample problems give students good practice at solving manageable parts of curriculum. But students need to experience some of the complexities as well, in order to appreciate how the parts fit together to form the larger whole. Without that perspective students tend to miss the big picture and not see the practice as relevant.

Grant Wiggins (personal communication, November, 1991) stressed the need for schools to engage in authentic assignments and evaluation. He cautioned against the over-use of

exercises which, in the students' minds, are not relating to their lives. "Even the dumbest kid on my soccer team knows that a practice isn't the game". By recognizing the patterns to be found in sample problems students can apply familiar formulae to solve new problems. This skill can be generalized to become part of the meta-analysis required of individuals attempting to solve more complex, real problems. Schools cannot stop at providing students with only practice; they must create and allow opportunities for students to carry the skills into the game of life.

Schools need to be aware of Feuerstein's (1980) list of cognitive deficits, as cited by Sternberg (1984), so that they might exercise vigilance in order not to contribute toward those deficits. Feuerstein's Instrumental Enrichment program was designed so that educators could mediate or remediate experiences for students who in turn could develop the cognitive structures needed to enable them to deal effectively with problems.

One such deficit is described as an ". . . episodic grasp of reality. The individual is unable to relate different aspects of his experience to one another." (Sternberg, 1984, p.41) Students need to see that sample problems are subsets of larger problems which should be related to the real world problems that might occur. If this is not rectified, students might miss the point of problem solving exercises.

There are sound reasons for allowing students to work on small, manageable parts of problems before setting them adrift on life's problem-filled sea. (Phillips Petroleum Company, 1977a, p.4)

> Modeling is thinking out loud, a way to find truth without consequence. Models are simplified representations of real objects or situations; with their help it is possible to test theories or predictions in whole or in part. When a problem contains many variables, modeling is often the only way to deal with it.

Not allowing students to test their developing process skills safely supported by debriefing, guidance and self-evaluation in arenas and situations students perceive as relevant, prevents them from recognizing the value of the practice and limits their ability to deal with reality. The greatest musician practises scales, the greatest basketball player shoots hoops, but they

also love to perform. Students need the *thrill of the game* mixed with the necessary repetition that comes from practice. Yet repetitive practice should not be mindless drudgery. The mind must be engaged in active processing if the repetition is to produce meaningful results.

Ideally, serious learning should be fun. It should be intellectually exciting, stimulating a push toward more learning. Young children learn vast amounts, at an incredible rate, through play. They take it very seriously. They use their play experiences and observations to gain understandings about their world. They manipulate and test their discoveries to make inferences and generalizations about the principles governing their environment. The researcher believes some of these factors might assist older learners to replicate and recapture some of those early learning tendencies and habits. In the mind of the researcher, this study was an opportunity to observe students learning some very important skills through *play* on a more sophisticated level. The flexible context offered the learners a chance to play with variables and look at theories from a variety of angles, test their hypotheses and arrive at some deeper understandings from which they may be able to generalize.

Michael Haynes, an entrepreneur, had approached the researcher in her role as consultant for a large school district. He wanted to offer a new product to students and staff. He was looking for a way to generate exposure for, and feedback about, a game he hoped could become a valuable educational tool.

A conversation ensued which revealed a mutual concern about the nature and purpose of schooling. Haynes expressed the business community's interest in receiving graduates capable of being successful in the world which exists beyond the boundaries of the schoolyard. He described concerns about the differences which exist between the skills needed to be successful in school and those needed once a student has left school. The

discussion progressed around themes relating to the role of problem solving, creative thinking and a teacher's ability to perform the task of assisting, through skills training, in the preparation of students for the world outside of school.

Points made included definition of the distinction between real world problems and the types of problems presented to students in thinking skills or subject-specific programming. Finally, the question arose as to how to best address the issue of what teachers could do to help students prepare for their future in a world which does not yet exist.

Haynes commented that he had done some reading in many of the same areas of interest as this researcher and wanted to contribute something of substance to this question. Part of his answer was to come up with a game he hoped would stimulate creativity through the playful application of a variety of thinking tasks.

What appeared to be a genuine concern on the part of a businessperson, to further the cause of education, struck a resonant chord with the researcher. Finding a way to blend community, home and school forces to advance the capabilities of students has long been a goal driving the researcher's ongoing professional development. An opportunity seemed to be presenting itself. Investigating the claims made about the game, *FFlow*, invented by Michael Haynes, seemed an appropriate vehicle through which to meet the previously listed criteria for designing a model of real world problem solving for students.

Haynes indicated his interest in having his game field-tested and agreed to allow students the educational opportunity to administer such testing as a mutually beneficial project. He would be getting feedback on his product and the students would have the chance to participate in genuine market research. Haynes would be available as a resource if students desired to question him about his product or creativity in general.

As part of her research study into real world problem solving, the researcher decided to extend to students Haynes' invitation to conduct market research. The role of the researcher would be to describe the process observed, and to facilitate the students' endeavours.

A description of the game will follow in chapter three, but it must be remembered that although market research on the game was to be the focus of the *students'* problem solving, it must be regarded as the translucent vessel through which the *problem solving process* would be examined by the researcher. The game itself was an integral component *only* as the catalyst for the market research task; it remained on the periphery of the problem solving process.

Limitations

The major limitation of this study was time. Real world problems are not conveniently scheduled to occur and be solved within a matter of six weeks. The sample of the problem solving process these students presented must be considered in light of the context itself. This study is based upon observations of high ability students working on a market research project. The students were to design a method for determining whether or not Haynes' game developed creativity. The students faced a variety of problems within the context of this task. This researcher interpreted the process as the students conducted their investigations and may be subject to observer bias. Since there are advantages and disadvantages of any inquiry format, the results and implications of the decision to structure the study in this manner will be reflected upon in chapter five.

Terminology

Since there are many terms and constructs from the literature which will be elaborated upon in chapter two, they will not be listed at this time. They will be italicized and individually defined when they are referred to and dealt with specifically. These terms will be reviewed

chapter five as they pertain to the discussion of the findings. For clarity of interpretation, the following terms are defined as they are used in this document.

Problem solving is used to describe the entire spectrum of problems being solved. This includes the solving of simple problems with clear structure to working on complex, ill-structured problems.

Problems range from very simple challenges to stubborn and complicated matters to be solved. A person can be presented with problems or can discover them. Problems are defined differently by those who face and who bring structure to them. The finding and formulating of problems is based upon the person's experiences and perceptions.

Real problems are taken to mean compelling problems which matter to the solver, and are related to the students' world, both within and outside of school. They are a subset of the entire spectrum of problems.

Academic Challenge is the term is used to describe the special-educational needs coding for able learners within the cooperating school district for this study. The culture of the district includes site-based decision-making and uses the coding as a basis for allocation of resources. Eligibility criteria for the coding are described in chapter three.

Although some stakeholders might include Academic Challenge students in their definition of ***gifted*** , it has not been the practice of the school district to assign that label to students who have met the aforementioned criteria. This is because the district believes all students exhibit strengths, and places responsibility upon teachers and administrators to meet the needs of all students, while formally recognizing the special needs of academically talented learners.

Unit — The students observed chose whether to work individually, in pairs or in small groups, so were termed *units* to differentiate among them and to accommodate the elastic nature of the groupings. A working unit consisted of one, two or more students as they approached their research task. The numbers of students within the units changed as students formed and dissolved groups during the course of the project.

Composites — are synthesized descriptors, forming an interactive model of problem solving. They encompass a blending of emerging themes from the research with related constructs from the literature, and are used to classify the factors influencing, and influenced by, the problem solving process observed through this study. The students' problem solving process is described according to these composites in their interaction with problem solving.

The text of this document contains many verbatim entries from the students' work. These have been checked for accuracy of transcription and are presented with errors intact. The decision to include student errors was made to illustrate that although these students were all identified as possessing high ability, their work is subject to messiness, errors in grammar, spelling, and imprecision of thought.

Overview of the document

What follows is a description of the problem solving process observed as a group of high ability students designed market research projects to test claims that the game *FFlow*, developed creativity. The total group conducting research numbered fourteen students. Of this pool, only five students were selected to be described in detail.

The document is divided into five chapters. *Chapter One* provides an introduction to the study, describing the reasons for the study which result from an ongoing concern on the part of the researcher regarding the problem solving abilities of students in schools. *Chapter Two* reviews the literature relating to problems, learning and problem solving, particularly as they relate to gifted students. *Chapter Three* outlines the structure of the research design. The researcher worked with a group of students on a market research project. She observed and recorded their problem solving process within the context of the task. The researcher then analyzed the data and interpreted the findings. Although fourteen students, in eight working units, took part in the research project, five students were selected for description. The work of all eight units provided voluminous data from which to discuss the problem solving process, so three of the units were selected as representative of the process observed. Five students were involved in these three units: two worked independently, while three students worked together as a team. *Chapter Four* describes the problem solving processes of these five students as they worked through the market research problem and problems emerging from the task. *Chapter Five* discusses the findings through the context of a model synthesized from the constructs presented from the literature and the themes emerging through the research. Each of the unit groups are discussed according to the composites forming the model. The researcher closes the document by reflecting upon the research study itself, summarizing and suggesting topics for further research.

CHAPTER TWO

A REVIEW OF THE LITERATURE

To live is to have problems,
and to solve problems is to grow intellectually.

J.P. Guilford (Eberle and Stanish,1980, p.43)

Problems are as common as air. Because of their prevalence, problem solving is a large part of everyday life. Much has been said yet little is known about what actually happens when people are solving problems.

In particular, the question of how gifted students work on real problems formed the basis of this study. A review of the literature uncovered many facets of problems and problem solving, which contributed to the belief that knowledge in this area is still evolving and the field is ripe for further investigation. There appears to be a scarcity of conclusive evidence regarding the process evoked by the problem solver.

Several questions guided a search for a deeper level of understanding. What exactly is a problem? What behaviors help or interfere with problem solving? What is the process people use when solving problems? How do people learn to effectively solve the problems they will face in their lives? Once charted or represented, answers to these questions could facilitate curriculum design and subsequently assist teachers interested in helping students help themselves.

Chapter Overview

Several things are at work simultaneously when an individual or group is working on a problem. How these components interact depends upon several factors. There are cause-effect relationships which facilitate or hinder solution to a particular problem and often lead to subsequent problems. The individual or group may not even be aware that a problem

exists. Once there is awareness, how that problem is represented or defined has an impact upon its resolution. Aspects of the problem may even change along the way, creating the need for an adaptive problem solving method.

Since the field of problem solving is so broad, it must be broken into manageable portions in order to be examined. One way to expedite investigation is to focus upon the following components, considered by this researcher to be present in all problem solving situations:

- problems,
- the uniqueness and role of the problem solver,
- the context in which problem solving occurs,
- the problem solving process, and
- the role of problem solving instruction and/or support.

These components will be described. The influences of the factors in their complex relationships with one another will be expanded upon and discussed.

Literature review

Many researchers and writers have contributed to the existing knowledge in the field of problem solving, each focusing upon one or more facets of the area. There is general agreement that the field is complex and interrelated. Many of the works support each other's conclusions and draw their inferences from the same sources. The works of Simon (1978) and Greeno (1973) are cited frequently, and references to the data from the same few actual studies continually appear in publications. To derive some wisdom from the plethora of writing is no small undertaking. Several common themes do tend to reappear, such as the interrelationship between problem solving, thinking and learning; problem structure and formulation; and metacognition and strategy use as behaviors of good problem solvers.

Excellent reviews of the literature on problem solving and learning are available elsewhere, but for the purposes of this review they have been referred to rather than replicated. Two major reviews provided useful overviews with several insightful observations. Schuell (1990) illuminated many of the aspects on phases of meaningful learning. Frederiksen (1984) commented upon the implications of cognitive theory on problem solving. In addition, several others offered lists of characteristics related to problem solving. Feldhusen, Houtz and Ringenbach (1972) determined cognitive behaviors, while Hoover (1987) summarized attributes of superior problem solvers (Feldhusen, Van Tassel-Baska & Seeley, 1989, chap. 16).

Briefly outlined below are some of the main points pertinent to this investigation.

- There are different types of problems.
- There seems to be a missing link between solving of well- and ill-structured problems.
- Finding and formulating problems is distinguishable from problem solving.
- How a problem is formulated influences its solution.
- There is little actual evidence from studies into ill-structured problems.
- Good problem solvers exhibit a variety of similar characteristics, such as metacognition and prediction of consequences.
- Learning is said to evolve through phases.
- Instruction contributes to effective problem solving and development.

PROBLEMS

Defining what constitutes a problem is requisite for developing an understanding of how it relates to the intricate process of its solution. Like the air around us, problems touch people in a profusion of ways. Of this plenitude some are so obvious they can be taken for

granted, overlooked or underestimated. They can exert pressure that builds. Others hit suddenly with gale force. They can be so complicated that their solution seems elusive or even impossible. By contrast, some solicit little thought or can be solved almost unconsciously through habit.

Bransford and Stein (1984) agreed with Blanchard and Johnson (1982) when they stated simply, "a problem exists whenever the present situation is different from a desired situation or goal" (Bransford and Stein, 1984, p.3). Although they did not belabor the point they assumed a continuum of problem complexity. Problems exist on as small a scale as opening a stubborn package of ketchup at McDonald's, or one so grand as the ecological impact of destruction of a rain forest to boost a developing country's economy.

The problems presented to, and encountered by, students in school range from the simple, finite questions structured with one right answer to more embedded, open-ended or less-structured challenges. The dimensions include: solving word problems from Mathematics texts or task cards, finding a pencil to work with, designing a research project and avoiding the classroom bully. The list expands exponentially. Increasingly, students are also being invited to become aware of complex problems relating to environmental issues, global economics, interracial prejudice, etc.

The works of Guilford (1977), Renzulli (1977), Sternberg (1985b) and Simon (1978) expand upon and form the basis for the previous definitions. Guilford (1977) defined a problem as a situation where the problem solver is neither fully prepared nor yet ready to immediately respond. There is a gap that must be spanned through the creative thought and action of the solver. "When there is need to go beyond the items of information that we have already structured . . . there is need for new intellectual activity." (Guilford, 1977, p.159).

A problem is not a problem until someone finds it so. Thus a problem remains only a potential problem until it interacts with, and exists for, the one or group for whom it poses,

"a matter difficult to arrange, or in which it is difficult to decide the best course of action" (MacLeod & Pauson, 1989, p. 537). A problem can take the form of, "a person, thing, or matter difficult to deal with; a question propounded for solution; a proposition in mathematics and physics stating something to be done; [or] an intricate unsettled question" (ibid, p. 537).

Moreover, the definition of a problem is tied to the difficulty of its solution, which may vary for different individuals. A problem may exist, but it might lie beyond someone's perception. That individual or group, therefore, would not consider it a problem until it enters their awareness and they feel the need to solve it. Further, what looms as a problem for one may not emerge significantly for another whose experience or training may have erased the novelty, prepared that person with an algorithm, or evoked a different definition. To assist with the examination of problems and problem solving some form of organization of problems may be useful.

Problem types

Ellis (1987, p.3) proposed a classification which groups problems according to a certain type or particular stage. These include:

- Information deficient,
- Idea deficient,
- Solution deficient, and
- Solution testing.

She went on to suggest that creative problem solving techniques are only required, as Costa (1981) suggested, when "you don't know what to do", when there is no obvious way to proceed, or when the obvious is not desired. This idea is also supported by von Oech (1983).

Problem structure

Simon (1973) elaborated upon the definition of a problem by classifying problems by their perceived structure. He drew a distinction between well-structured problems and ill-

structured problems. For someone who recognizes the type of deficiency a problem presents, and who feels he or she knows how to solve that problem, it might not be considered ill-structured. Several authors concurred that perception plays at least a partial role in assigning or classifying problem structure (Frederiksen, 1984; Getzels, 1985; Sternberg, 1985b).

Frederiksen (1984) clarified this distinction when he cited Simon's (1978) definition of well-structured problems as those which require mainly the information presented through a problem statement. Ill-structured problems are more complex, do not provide all the information required for solution, and have no predetermined set of correct moves toward solution. According to Frederiksen, ill-structured problems lack "a clear formulation, a procedure that guarantees a correct solution and criteria for evaluating solutions. Most social and political problems and many scientific problems would fall in this category" (Frederiksen, 1984, p.367). The issue of the impact of problem structure upon problem resolution is further clouded by the definition and nature of the problem. Frederiksen (1984, p. 366) cited Simon (1978), who

> . . . believes that the processes are basically the same for solving well- and ill-structured problems, but for ill-structured problems one's conception of the problem alters gradually as new elements are evoked from L[ong] T[erm] M[emory] or from outside sources, and a wide repertory of recognition processes is necessary to evaluate whether one is 'getting warmer' as a result of each altered state.

Studies have shown that students may be adept at solving well-defined problems but there is not a great deal of evidence about what happens when students are working on ill-structured problems. (Kanevsky, 1990; Kitano, 1985; Ludlow and Woodrum,1982). Educators and researchers seem to have overlooked the transformation that occurs as the structure of a problem becomes more obscure. Rather than a chasm, there is likely a progression of incremental problems that can be spanned through training and experience. Another facet of this is the contention that "the problem is well-structured in the small but ill-structured in the large" with more research needed into what happens between the two (Simon, 1973, p. 190). Researchers need to build a pathway for studying the changes in

complexity problem solvers encounter as they move along the continuum toward ill-structured problems.

Another part of the connection lies with the evolutionary nature of ill-structured problems. Since problem recognition and definition are influential in problem solving and they change as new elements of an ill-structured problem are evoked; the problem solver must be ready to adapt "on the fly", so to speak. Strict, mechanistic and rigid adherence to a predetermined set of rules or processes prevents the learner from a fluid interplay of skills which may be necessary for solution. Also, how the solver structures the problem is related to how he or she proceeds with a solution (Marzano & Arredondo, 1986).

Since many researchers agree well-structured problems are most commonly used in social studies and science *coursework*, a contradiction may arise. If the problems within these disciplines are ill-structured, it raises a question regarding the appropriateness of the exclusive use of presented problems, particularly in such subjects as science and social studies. Could it be that the majority of the well-structured type of problems selected for coursework might actually be interfering with the intellectual development of students? The answer to this question is not likely to be a simple yes or no, for it has its roots in many other areas, including context, training, motivation, age, readiness and ability of students.

Furthermore, Frederiksen (1984) argued with the oversimplification that implies there is a dichotomy between well-structured and ill-structured problems. He used Greeno's (1973) descriptions of productive thinking and reproductive thinking to suggest that there is at least one additional category of problems that challenges learners. He injected "structured problems requiring productive thinking" (Frederiksen, 1984, p.367) between the well- and ill- points along the problem structure continuum. Problems classified this way are explained as those which are similar to well-structured problems, like puzzles or mathematical word problems, but some aspect of the procedure must be generated by the problem solver.

It is this third category that seems to possess great potential as the bridge teachers and students need to utilize in order to facilitate student development and transfer of the skill of problem solving. Since transfer of skill is seen as the critical product of problem solving training, this aspect is highly significant. Perhaps this is the threshold of real problems, because it links the problem to the world of its solver while still belonging within the realm of problems which experience some external influence by teachers.

Real Problems

Renzulli (1977) submitted the classification of *real problems* for explaining the shift from consumer to producer of knowledge, particularly within the context of research or project development. He described such problems as, "similar in nature to those pursued by authentic researchers or artists in particular areas of study" (p. 31). Sternberg (1985b) built upon this and Simon's (1978) notions when he discussed real problems in the context of those which are encountered in everyday life. He differentiated between clear-cut, presented problems usually provided to students in school, and those messy and stubbornly persistent problems of everyday life.

Treffinger and Isaksen (1992) established working with real problems as the goal and essential third component of a three-phase instruction model for thinking skills training utilizing their Creative Problem Solving process. Treffinger differentiated a real problem from others by describing it as one that is "pertinent, intensely involving and demanding" in which the problem solver is immersed and committed to action (Treffinger, personal communication, 1992). It is this dynamic relationship between problem and solver which seems to propel much of the problem solving process.

Another unique feature of this relationship is that it generates a spiral path for the development of the problem solver, since some of the confusion in solving ill-structured problems is that they share similarities with life itself. The choices people make will often cause them to go off on routes which alter the courses of their lives. Since the

consequences shape the next set of problems, the person has to adapt to the *changed* set of features. So a solution that might have worked before may no longer be appropriate. There is often no way to go back and test whether or not a hindsight solution would have worked, nor yet any way to go back in time and change the original choice.

When researchers are investigating problem solving, the nature of the problem being solved greatly impacts the data and subsequent interpretations. Kanevsky (1990) recognized this issue when she examined problem solving strategies employed by students. She raised the point that, for her study, students were working on a well-defined task. She claimed that the well-defined nature of the problem she presented had a strong bearing upon the information she was able to glean from her data. She asserted it was both an asset and a liability. She allowed that the well-structured problem permitted clean performance assessments and analyses. However, she cautioned that it was a far cry from the ill-defined problems children learn to solve in day-to-day life, and insisted, "This must be kept in mind when attempting to generalize trends found in these results to academic or real-world problems" (p. 137).

Problem evolution

Another aspect of the classification of problems deals with the point at which the individual solver contacts and defines a problem. Bloom (1956) stimulated consideration of this aspect when he offered the important distinction between application of existing knowledge and synthesis of new knowledge. In application, the student functions as a consumer in a new but similar arena. This activity is practising acquired skills. However, "in synthesis, . . . the student must draw upon elements from many sources and put these together into a structure or pattern not clearly there before" (p.162). For example, two students might give the same response to a question. For one, the answer may be simple recall of existing knowledge; while for the other, the same comment might represent a sudden inspiration or coalescing of several puzzling ideas. This same phenomenon may be true of the point at which a solver recognizes a problem. To a novice, a situation may seem ill-

structured and complex, while to a seasoned veteran it may simply require application of a familiar formula.

It is the novel or original combination of elements to produce a new creation which deserves attention as the floating decimal point along the continuum scale of problem complexity. Rather than a dichotomy between problem types, perhaps the argument is a philosophical discussion of whether this is a difference of degree or kind (Lipman, Sharp, & Oscanyan, 1984). Where a problem settles along the continuum may depend upon where the classifier decides to punctuate it. This concept is supported by Frederiksen (1984, p.367).

> The category in which a given problem falls obviously may depend in part on the problem solver. A problem may be well-structured for the problem solver who possesses the requisite knowledge and has practised the relevant problem-solving procedures, or it may fall in one of the other categories for one who has had insufficient experience or training in solving problems of that type.

When problems are repeatedly solved, they become routine and cease to demand the same energy for solution as they did the first time they were encountered. Further, they can be grouped or regrouped in flexible categories of problem solving and can also be combined to generate new solutions. Current research into brain and memory function would seem to support this notion. Combinations of singular skills may become linked, and may be retrieved from memory as a procedure (Frederiksen, 1984; Phye, 1990; Sylwester, 1990; Weed, Ryan & Day, 1990; Zentall, 1990).

Zetlin (1993) examined how learner response to problems changes with experience. He cited Haier's work with brain imaging technology whereby subjects learning a new video game used a tremendous amount of brain energy to do seven lines during the initial phase of the game. When retested a month later subjects performed fifteen times as well on the game "but the P[ositron] E[mission] T[omography] scan showed that they used less brain energy to complete 100 lines than to complete seven. And the greatest drop was shown by the subjects with the highest IQ's " (Zetlin, 1993, p.6).

Roger von Oech (1983) added to the idea of problem evolution when he suggested that for dealing "with the business of everyday living, we have developed routines which guide us through our day-to-day encounters—everything from doing paperwork to tying our shoes to dealing with telephone solicitors" (p. 8). These habitual, even mindless, encounters might be construed as the lowest order problems defined above. They may exist, now in the present tense, as habits, but their establishment as such routines might well have been considered creative in the past, while the routines were still in the early, building stage.

Thus although innocuous, benign and mundane problems can usually be alleviated through a repetitive category of solution, the door needs to be left open for considering them to be a type of inventive problem solving such as Bransford and Stein (1984) or Guilford (1977) might describe. Further support came from von Oech (1983) who contended routines are essential for getting most things done. However, once upon a time they could have been considered problem solving. For new challenges, or habits in creation, the problem solving process is currently being evoked. He submitted "there are times, however, when you need to be creative and generate new ways to accomplish your objectives" (p. 8). This does not preclude habituation as problem solving, rather it places it along a chronological framework.

This suggested classification of problem finds support under a different name. Although termed to be creativity by some, and supported by many (Juntune, 1990; Parnes,1985; Sternberg, 1984) as such, this researcher contends that the commonsense view is one of *creativity-turning-to-habit.* Therefore, when novel problems evoke problem solving using this definition, creativity is viewed differently. It becomes a form, and perhaps a synonym, of problem solving. Problem evolution then, takes place within the solver as the problem ceases to be novel.

Taylor (1974) offered another dimension that seems to link with the concept of the problem solving function of creativity when he suggested, "The creatively talented are not only

thinkers, but producers of original ideas, products, and methods; they often solve problems uniquely but appropriately"(Juntune, 1990, p. 8).

Similarly, how a problem is defined by the solver shapes its structure and solution. This is often represented by the questions the learner uses to fashion an interpretation of the problem (Getzels, 1985). For this reason, an examination of the nature and influence of the problem solver seems in order. There are many factors influencing the solver's approach to a problem and the decisions made when attempting to solve it.

Summary

Problems can be defined in various ways, depending upon the degree of structure they present and the type of energy, thought and commitment they evoke in the problem solver. Real problems are often lacking in structure and require creative approaches initially. But with time and repetition, they may cease to be considered problems at all. An appropriate, albeit creative, solution becomes habitual. A solver can usually leave well-structured problems behind, but ill-structured problems continue to evolve.

THE UNIQUENESS AND ROLE OF THE PROBLEM SOLVER

Information Processing

Since much of the following examination of how the solver interacts with the problem depends upon the solver's thinking, a context or frame of reference would be useful. Costa (1984) suggested a simplified model of brain function. Three main categories of brain activity are described. During the Input phase the brain is constantly taking in information through the senses. The Processing phase is crucial: the brain classifies, analyzes, stores and makes decisions about the information. Action upon the information occurs during the Output phase. Knowledge of these phases has implications for developing an understanding of the nature of the problem solving process.

Problem finding and problem formulation

Probably the greatest role of the problem solver is that of determining the problem. The way a problem is defined will affect its solution. Bransford and Stein (1984) used a grease-splattering frying pan as an example of this phenomenon in action. Depending upon whether the problem solver defines the problem as one of a fire that is too hot, a burn danger for the cook or that of a hazard posed by hot grease rising quickly and travelling long distances, will determine how that person will devise ways and means of solving the problem. Whether the cook reduces the cooking temperature, uses protective clothing or invents a splatter screen will be directly related to the definition of the problem.

Getzels (1985) conducted a longitudinal study of the relationship between the quality of solutions in the work of artists and how well the artists were able to find and formulate problems. His conclusions led to the proposal that the crucial role of finding and formulating problems in creative thought is very closely related to the field of problem solving. He cautioned, however, the skills of problem finding, problem formulating and problem solving should be distinguished from one another. Obviously they are also interlocking, but Getzels (1985) contended that they appear to be distinctly developed to different degrees within individuals. He did not place greater importance upon one over the others, but he suggested further, "the quality of the problem that is formulated is the forerunner of the quality of the solution that will be attained" (p.56). His distinction is well accepted by numerous other researchers. (Bransford and Stein, 1984; Crabbe, 1985; Feldhusen, Van Tassel-Baska & Seeley, 1989; Hoover & Feldhusen, 1990; Myers, Slavin & Southern, 1990; Sternberg, 1985b; Whimbey & Lockhead,1982).

Another facet of problem formulation lies in classification. With gifted students in particular, it is not just a simple case of defining a problem which Parnes (1985); Eberle and Stanish (1980); and Treffinger and Isaksen (1992) called developing problem

statements. When gifted students are *mess finding* or *problem sensing* they may see a variety of ways of classifying messes, so converging upon problem statements may be difficult. Often one of the most maddening aspects of a problem for a bright child, may be to decide upon which definition of the problem is the best one on which to focus attention. Choosing the priority definition is not always done consciously, yet by alerting students to the difficulties associated with this phenomenon, they can begin to utilize both divergent and convergent thinking to generate different definitions and choose the one they deem most appropriate.

Hoover and Feldhusen (1990) conducted an investigation of hypothesis formulation ability among gifted ninth-graders about a somewhat ill-structured but realistic problem situation. The study was mostly concerned with test administration and did not make observations about what the students actually do when solving an ill-structured problem. They explored gender differences, problem finding relationships to cognitive and non-cognitive variables and quality and quantity of ideas. Their results suggested that girls should be as capable as boys in formulating hypotheses, that intelligence is independent from the ability to formulate hypotheses and that there is a correlation between the number of ideas and the quality of ideas generated. They cautioned that there is a distinction between problem finding and problem solving and called for additional work in that area.

Asking questions

A problem is partly formulated and defined by the questions the solver uses consciously or unconsciously to frame it (Eberle & Stanish,1980; Ellis, 1987; Frederiksen,1984). Minteer (1953, p.102) offered an important distinction through the labels, "Useless questions and answerable questions", for example, "Why aren't I popular?" vs "Where can I learn to dance?" Perhaps the formulation of useful questions, appropriately applied to ill-structured problems, would go a long way to transforming them into structured problems requiring productive thinking.

A caution with this notion is akin to a possible problem with misinterpretation of Treffinger and Isaksen's (1992) Creative Problem Solving (CPS) model. During the first phase of CPS, *understanding the problem*, the solver develops mess statements, generates and compares facts about the problem, then focuses on creation of problem statements for defining and formulating the problem. The difficulty lies with the appearance of a linear sequence. There is a danger in assuming the solver has defined the problem in order to formulate a useful question or clear problem statement. There is a possibility, especially for a complex, or ill-structured problem, the solver may have to repeat the steps as many times as necessary before unearthing the core of a deeply embedded problem. There is even the possibility that the repetition of the steps is the route to unearthing the core.

Jensen (1978) offered additional support through a heuristic for problem formulation by suggesting a number of dimensions from which to analyze a problem. The use of questions regarding substantive, spatial, temporal, quantitative and qualitative dimensions may assist the solver in determining the scope of a problem.

Behaviors of good problem solvers

Intertwined with problem solving are the growth and learning that come from both successful and unsuccessful attempts to solve problems of any dimension and their cumulative effect upon the solver's subsequent approaches and repertoire of strategies. What the learner brings to the problem solving situation and what he or she leaves with are seen as crucial to definition and selection of optional routes from one situation to another.

Feldhusen (1989) suggested that "problem solving possibly involves a complex set of cognitive operations that are basic components of several types of thinking skill" (p.249). These cognitive operations included concept formation, language, perception, reasoning, basic skills and achievement (Feldhusen, Van Tassel-Baska & Seeley, 1989). Hoover (1987), through a review of research on superior problem solvers, concluded that there are several characteristics of good problem solvers, including the ability to structure ambiguous

tasks, problem identification, metacognition, effective information and strategy use as well as other components which would seem to support the works previously cited.

Good problem solvers tend to use these cognitive operations as the means to think well. They do not, however, need to think well only on school-related tasks. Sternberg (1984) and Gardner (1985) have both added to the notion put forth by Guilford's (1966) structure of the intellect. The concept of multiple intelligences honors "street smarts", musical or bodily kinesthetic intelligence and other ways people may elect to solve problems. Getzels (1985) referred to art as yet another, though perhaps slightly uncommon, view of problem solving. Depending upon the task, good problem solvers seem consistently able to function with less than optimum information and make good decisions with the information they have. This begs the question of whether or not gifted students are automatically good problem solvers.

Problem solving and gifted students

Ludlow and Woodrum (1982) drew attention to the irony which the issue of giftedness and problem solving raised when they cited several studies which characterized gifted students as possessing superior problem-solving ability, but pointed out that there had been few experimental studies investigating the nature of this ability. They described the evolution of problem solving as partially dependent upon stimuli and feedback conditions and partially dependent upon how the student organizes his thinking. They hypothesized perceptual, memory and conceptual organization as possible explanations for the use of improved strategies. Very recent brain research is lending support to many of these ideas. (R. Sylwester, personal communication, December, 1992). Ludlow and Woodrum's study involved investigating the strategies employed by gifted and average learners working on a strategy game involving deductive reasoning. Their conclusions were significant because they suggested that problem solving abilities do not develop spontaneously, and did not support the notion of naturally occurring superior problem solving within the gifted population.

Flexer (1987, p. 120) added fuel to this argument when she cited Lester (1980) in offering descriptions of good problem solvers, "They are interested in solving problems, confident in their abilities to do so, willing to take risks, productive in finding alternative approaches and solutions, able to evaluate trial solutions, and able to find unusual solutions". Her observation that conventional methods for identifying gifted students by test scores selected the *poorer* problem solver, prompts researchers to question the assumptions about gifted students and problem solving.

Just as the individual or group's perception of a problem influences its definition, so does an individual or group's conception of giftedness affect the identification and definition of the gifted population. That definition could have a significant effect on the interpretation of data from an investigation into the process used by gifted students as they solve problems.

In 1972, the Marland Report challenged many stereotypes by offering several areas in which potential or demonstrated ability might be recognized and then made recommendations about differentiated programming. Through its multifaceted view and definition of giftedness, more children were being given consideration of their educational needs. The report acknowledged intellectual ability, academic aptitude, thinking, leadership, artistic and psychomotor ability as indicators of giftedness. As well, Renzulli (1977) presented his well-accepted model of giftedness based on behaviors that are a result of the intersection of at least three characteristics: task commitment, creativity and above average ability. Since that time many researchers have built upon the ideas put forth to arrive at a commonly accepted view of a pluralistic nature of giftedness. (Gardner, 1985; Sternberg, 1984; Taylor, 1974).

Sternberg and Davidson (1987) compared and contrasted the conceptions of giftedness of a number of scholars to draw attention to the inclusion or exclusion of various individuals depending upon the criteria used to define the gifted population. Some of these characteristics include "insight and an individual's willingness to persever [sic] and stick to the development of excellence . . . in the face of conflict" (Sternberg and Davidson, 1987,

p. 6). It follows that these traits would seem to have a direct bearing upon an individual's problem solving process.

Although the contributors held varying viewpoints about who was gifted and how giftedness might best be studied, all definitions reflected the Marland report's influence and emphasized attributes which depicted giftedness as "an interaction of systems" (Sternberg and Davidson, 1987, p.15).

> Csikszentmihalyi and Robinson, Feldhusen, Feldman, Gallagher and Courtright, Haensley, Reynolds, and Nash, Renzulli, Tannenbaum, and Sternberg all define giftedness as involving multiple qualities. These qualities are not just intellectual. All of the investigators argue that giftedness involves social and motivational properties as well. All view IQ scores as inadequate measures of giftedness. Task commitment, high self-concept, and creativity are explicitly mentioned by many or all of these researchers as being among the defining qualities of giftedness.
>
> (ibid p. 418).

Seeley (1985) offered the additional facets to the construct of intelligence with his notion, based upon the work of Cattell (1963), of how *fluid* intelligence and *crystallized* intelligence affect problem solving. Seeley (1985, p.77) defined crystallized intelligence

> . . . as intellectual functioning that requires previous training, education, and acculturation. This kind of ability uses verbal mediation, sound inference, and sequential steps of logic in problem solving. Fluid intelligence is defined as problem solving in which quick adaptation to unfamiliar stimuli is used to understand the implied pattern or concept with little reliance on previously learned strategies or verbal mediation.

This concept seemed to be supported by the works of several researchers. It is related to Flexer's (1987) constructs of extrinsic and intrinsic styles of problem solving and Treffinger's (1992) adaptation of Kirton's (1976) description of adaptive and innovative creativity as well as de Bono's (1985) validation of "red hat thinking" which Clark (1979) saw as an emphasis on intuition and Sternberg and Davidson (1982) described as selective encoding and insight. Another interesting note in Seeley's (1985) work is that it was "the high level of fluid abilities that most accounted for the giftedness found among the delinquent group studied"(p.77) and that many underachievers exhibited high ability in nonacademic areas. He continued by suggesting that

> . . . fluid intelligence has further been defined as being developed by incidental learning, and distinctly *not* taught or used in school. Students who

> use this ability in problem solving or as a learning strategy are often penalized in classroom instruction, which rewards convergent, logical responses.

Kitano (1985) looked at giftedness as it relates to behavior. She conducted an ethnographic study of gifted preschoolers and found they behaved similarly to unselected preschool children. She was using naturalistic observations of the gifted sub-group and found many connections with the larger group of all preschoolers. She also found individual differences. Although her subjects were all identified and classified as gifted, they were not the same and did not act in the same way. She observed, "while these descriptions characterize the group as a whole, each child within the group demonstrated a unique set of behaviors and traits. Individual differences appeared to be more salient than differences between cultural groups" (p. 71). It would follow then that gifted students might also approach problem solving in different ways.

Kanevsky (1990) explored gifted students and problem solving of well-structured tasks. She found differences in the way young high IQ children understood and owned problems, learned from mistakes when solving them, and used their experience to generalize to similar problems. She submitted"flexible access and application of knowledge are fundamental characteristics of effective learning, problem solving, and cognitive development"(p. 135).

Another attribute of gifted students is their sensitivity. They often display greater concern with the more global problems facing humanity than do their same-age peers. Investigating the process this group uses to solve progressively more complex problems forms one of the reasons for this study. But sensitivity toward problems is not to be confused with skill in solving them.

Among the many lists of characteristics describing gifted students, superior problem solving abilities are frequently cited. (Feldhusen, Van Tassel-Baska, & Seeley, 1989; Gallagher, 1985; Van Tassel-Baska, Feldhusen, Seeley, Wheatley, Silverman, & Foster, 1988). Since gifted students are sensitive and commonly believed to have problem solving talent ingrained, they are most often charged with the responsibility of taking on the

world's problems (Berman, 1990). Thus creative problem solving is frequently suggested as an essential part of gifted programming, although, as Ludlow and Woodrum (1982) posited, there is much yet to be learned about what gifted students actually do when solving problems. As well, the structure and types of problems utilized in creative problem solving training may not be appropriate for arriving at these ends (Sternberg, 1985b).

Moreover, potential is not always realized, and the assumption that giftedness naturally leads to good problem solving requires additional scrutiny. Problem solving itself is often described as a thinking skill. Yet not all intelligent people are necessarily good thinkers (Covington, Crutchfield, Davies & Olton, 1972; de Bono, 1985; Nickerson, 1991; Paul, Binker, Martin, Vetrano & Kreklau, 1989). Often through experience and training students improve their thinking skills. It would follow that problem solving could also be nurtured and perhaps good problem solving ability is not as automatic in gifted students as some might expect. How best to address the problem solving process development in school becomes another question for investigation. Some studies point to a need for further discussion on this aspect of giftedness. (Flexer,1987; Gallagher, 1985; Kanevsky,1990; Kitano,1985; Ludlow and Woodrum,1982; Myers et al., 1990)

Research into giftedness remains incomplete. There are diverse opinions regarding the construct of giftedness. Knowledge of how gifted students solve real problems in school is even less explored. But there seems to be support that understandings and answers might possibly emerge from the study of the actual situations where real problem solving happens. Because ". . . our really trenchant insights about giftedness have evolved from the intensive study of small numbers of cases. . . these investigators clearly believe that giftedness will best be understood in the context where it occurs, rather than in laboratory settings" (Sternberg and Davidson, 1987, p. 15). Flexer (1987, p.122) lent support to this methodology by affirming the validity and use of clinical interview as a model for research. She suggested, "Each case study contributes to a more complete picture. Generalizations about children's . . . behavior cannot be made from a single study but rather from the accumulation of findings from many studies".

This diversity of opinion about the definition, and existence or absence of giftedness also calls for focusing upon elements which are less in dispute. Feldhusen (1989), in a synthesis of research on gifted youth, cited Renzulli (1970) stressing, "that it is more productive to focus on gifted behaviors than to attempt to determine whether or not children are gifted" (Feldhusen, 1989, p.6).

Intelligent behavior

Different studies have attempted to build upon Renzulli's suggestion by focusing on the behaviors of students rather than emphasizing whether or not they have met criteria for giftedness. Coleman and Shore (1991) examined the differences between high and average performers in Physics. They studied the behaviors of novices and experts and found that the high performers monitor and evaluate the processes they employ and utilize previous knowledge.

Costa (1984) was concerned with developing intelligent behavior, which as he explained is,"knowing what to do when you don't know what to do". He listed several intelligent behaviors such as metacognition, persistence, withholding judgment and reduced impulsivity. Nickerson (1991) claimed that many of these are attitudinal variables, and are equally critical as anything else in determining quality of thinking which leads to intelligent behavior.

The concern raised by Costa and Nickerson regarding the use of intelligence to guide behavior was shared by Skemp (Sfard, 1990). He was more interested in how intelligence functions than its measurement. Skemp used the analogy of money in the bank. He was not against its measurement, but was more interested in what was done with the quantity (Sfard, 1990, p. 50).

> If you didn't know what money is for, what a great resource it is, and all the things you can do with it, it would be useless. You could starve in the midst of plenty if you didn't know that by taking your money to a shop you could get food. Therefore, what you can do with your intelligence is what my model is largely about.

Not only intellectual giftedness, but the effectiveness of the problem solving process employed by gifted students is of the utmost interest and importance to this researcher. So this study must include attention to the creative results of the process, not just recording the mechanistic application of a sequence of arbitrarily assigned steps or the potential ability of the solver. For that reason creativity is another behavior for examination; it too, is commonly associated with giftedness and problem solving.

Intelligence, Creativity and Problem Solving

Although problems have always existed it took insightful thinkers to link creativity and problem solving and bring them to the attention of modern psychologists and educators. An influential forerunner to this issue is Guilford. His presidential address to the American Psychology Association in 1950 stimulated attention to the scientific study of creativity and gave credence to the concept of divergent thinking (Keating, 1980).

Guilford (1977) suggested that problem solving has creative aspects in that creative thinking produces novel outcomes. Through problem solving, new responses are generated; this might be regarded as constituting creative outcomes. Therefore, Guilford indicated that problem solving may be considered a subset of creativity. On the surface Guilford acknowledged that creative endeavours may not seem like problem solving, but suggested a broader conception was necessary, for example, an artist's problem may be one of self-expression.

The ability to solve problems has often been linked with intelligence and creativity. Although these attributes may play a part they are not the total determinants of an individual's success with problem solving, again a broader conception is necessary. Some studies have shown the more intelligent students, considered gifted by IQ measures at least, are not necessarily the most successful problem solvers. (Flexer, 1987; Ludlow and Woodrum, 1982). The realization of potential seems to require something more than creative and intelligent ideas. Whether a subset, a synonym, or something greater,

successful problem solving reflects many attributes of each. Good problem solving seems to move the solver forward. The solution of problems leads to new levels of intellectual development.

This brings in the element of using criteria for judging creative thinking. Many people working with creative problem solving incorporate this blend of divergence and convergence as essential to good thinking. Critical thinking and creative thinking are two sides of the same coin. To think well creatively is to think well critically and vice versa. Good analytical skills are not enough, ideas must first be generated before they can be evaluated. Often decision making and planning skills have been relegated to the realm of critical thinking, yet both are needed to solve problems creatively. A marriage of critical and creative thinking is needed to generate a good range of options and choose the most appropriate course of action. This balanced view of effective thinking is supported by many (Covington et al., 1972; de Bono, 1985; Eberle & Stanish, 1980; Juntune, 1990; Parnes, 1981; Perkins, 1986a; Treffinger & Isaksen, 1992; von Oech, 1983).

Due to the range of complex problems facing the world of today, this broader view of creative problem solving ability is believed to be one of the most marketable skills of the future. Some American states even hold future problem-solving competitions co-sponsored by the corporate sector (Crabbe, 1985). In spite of the variety of opinions regarding whether and how problem solving should be taught, there is little disagreement that problem solving is one of the most important skills students, in particular gifted/talented students, need. (Costa, 1985a; de Bono, 1985; Gallagher, 1985; Sternberg, 1985c; Renzulli, 1977; Treffinger & Isaksen, 1992).

Motivation

Treffinger, Sortore and Cross, (1992, p.11) cited Talbot (1991) when they suggested that during the solving of real problems, important concerns are emphasized relating to motives, opportunities and means. Each is important, but the one that quite possibly *drives* problem solving, is motivation. Biggs and Telfer (1987) classified motives for learning or

performing a task into four main categories. These are related to Kohlberg's stages of moral reasoning (Clark, 1979, chap. 3), and are labelled Instrumental, Social, Achievement and Intrinsic motivation. The instrumental learner acts because of the consequences, positive or negative. The socially motivated person is looking to please people whose opinions are important to him or her. Achievement offers the lure of enhancing the ego, and encourages competing with others to feel good. Intrinsic learners do so because they want to, out of curiosity and joy. The degree of pay-off from one or a combination of these categories may offer the solver reason to persist with structuring and solving a problem.

The results and goals associated with motivation are sometimes considered to be culturally based and are often expressed through stereotypes. Achievement motivation in particular, is linked to productivity. However, motivation is not limited to any one culture; it underlies all of them. Brendtro, Brokenleg and Van Bockern (1991) introduced a model, illustrated by Blue Bird, of four interrelated categories of needs and feelings of self concept which predispose behavior. These four components of human character, supporting the work of Coopersmith (1967), are described as central values: Belonging, Mastery, Independence and Generosity which are reflected through needs and govern motivation. If these attributes are normally developed an individual's behavior is positive and constructive. If these categories are distorted or absent, the person manifests aberrant behaviors and is easily influenced toward counterproductive choices. For example, in the category of Mastery, normal development presents a creative, persistent, motivated and competent problem solver. If not developed normally, real problems permeate young lives. (Brendtro, Brokenleg & Van Bockern, 1991, p.11)

> Frustrated in their attempts to achieve, children may seek to prove their competence in distorted ways, such as skill in delinquent activity. Others have learned to retreat from difficult challenges by giving up in futility. The remedy for these problems is involvement in an environment with abundant opportunities for meaningful achievement.

Style

Style is affected by motivation. There are many facets to the construct of an individual's style. Learning style, problem solving style, leadership and psychological style all provide lenses through which to examine learners and problem solvers.

Flexer's (1987, p.120) work developed the construct of a style of problem solving. She used clinical interviews with two high ability first-grade children on alternate weeks over an academic year. She proposed a

> . . . pair of polar problem-solving styles defined by these contrasts: an *extrinsic style* in which procedures for finding and evaluating solutions exist outside the child, and an *intrinsic style* in which the child develops and evaluates solutions. The extrinsic problem solver focuses on getting the correct answer; the intrinsic problem solver also has a correct answer as a goal but focuses on the analysis of the problem and on the method of solution. . .

Using mathematical problems, Flexer observed how the children approached finding a solution. She noted their styles of solving problems were quite different. The male student, identified as gifted, searched for rules to apply and could apply them fairly skillfully. His primary concern was arriving at correct answers. He seemed to lack confidence and continually sought verification from an outside source. The female student developed her own methods of solving problems and seemed to enjoy the process.

Myers, Slavin and Southern (1990) investigated the individual differences in gifted adolescents' leadership styles as well as student attitudes toward leadership style when groups approached an ill-structured task. Myers et al.'s descriptions comprised a range of styles including Authoritarian and Participative styles of leadership. They found that the effectiveness of group problem solving was related to group perception of leadership effectiveness and group product creativity.

Another element of style is the construct of individual learning style. Several theorists draw attention to the ways in which students learn (Dunn, Dunn & Treffinger, 1992; Gregoric, 1980; McCarthy, 1980). They all reinforced the concept of the varying ways in

which students receive and process information. The companion to this is the teachers' responsibility for creating learning activities to accommodate a variety of styles.

The Myers-Briggs Type Indicator is another popular instrument for assessing learners. It offers classification and identification of psychological type. The *bipolar dimensions* (Meisgeier, Murphy & Meisgeier, 1989) are facets of how an individual focuses attention, receives information, makes decisions and orients to the world.

The labels for these continua include sub-categories of the functions of Sensing/Intuition, and Thinking/Feeling, as well as the attitudes of Extroversion/Introversion, and Judging/Perceiving. Classifying people this way leads to understanding how they approach situations and make decisions about the information they absorb from those situations. The implications of this type of assessment have to do with providing support, developing relationships and interactions with students. It also invites adults working with students to consider the impact of their own style when addressing people of similar or differing styles.

Summary

Although the individual formulates the problem, many things are influencing the individual during this formulation. Defining a problem has to do with determining what the problem is. How that individual perceives the problem is related to several things: intelligence, motivation, creativity, style, the ability to structure the problem and the context in which the problem functions.

THE CONTEXT IN WHICH PROBLEM SOLVING OCCURS

Interaction of problem and solver

The interaction of problem and solver raises the "chicken and egg" issue of the situational influence of context upon problem understanding, prediction of consequences and strategy

selection. Appropriateness or effectiveness of problem solving strategy selection is based upon a myriad of factors, not the least of which is the context of the situation.

It is also argued and supported by Frederiksen (1984) and Sternberg (1985b) that the context or point at which problem solvers finds themselves has at least a partial basis in perception as well as in conjunction with fact. This also contributes to the understanding of the problem, the creative productivity for generating alternatives and criteria for evaluation of choices for solving it. Treffinger, Sortore and Cross (1992) suggested this is a function of *COCO*, the Characteristics of people, and the Operations they perform in their Context leading to Outcomes. These comprise the climate for good problem solving. They based some of this on the work of Les Jones (1992) when they explored personal and group blocks and barriers to creativity. These included External as well as Internal barriers. Internal barriers consist of: Strategic or preferred methods for solving problems, Values or the degree of flexibility in applying beliefs, Perceptual or the use of senses and awareness and Self-Image which is the individual's assertiveness and confidence in his or her abilities. Treffinger et al. also based some ideas on the work of Ekvall (1983) when they addressed the group climate for creativity

Sternberg (1985b) added that appropriateness of a solution will also be shaped by its context, "the solutions to everyday problems depend on and interact with the contexts in which the problems are presented" (p. 196). Bransford and Stein (1984), Frederiksen (1984) and Getzels (1985) all agreed that the definition of the problem directly affects the choices leading to solution.

Thus, as previously stated, how a problem is defined affects the context of its solution. The context of the problem affects how it might be defined. And how the problem solver perceives the problem *and* its context affects how the problem will be defined and approached. The recursive nature and complexity of this relationship is cause for some of the difficulty surrounding the study of problem solving.

Once a problem is determined, the problem solver then selects from a number of pathways how he or she is actually going to move from one point to another. Since each pathway leads to a subsequent context, the solver needs to consider the impact of the decision. To return to the problem continuum stated earlier, even the simple problem of opening a ketchup packet at McDonald's can lead to subsequent situations. The choice to puncture it with a fork might lead to a problem of how to clean ketchup off clothing.

Moreover, when a recognized problem is conquered, it is often a cause for celebration, either public or private. Whether it comes as a prestigious award, relief, or the subtle smile and personal enjoyment of an "aha . . ." (Parnes, 1981, p.5), it might be assumed much of the satisfaction human beings experience is derived from the solution of problems. Therefore this researcher proposes the notion that effective problem solving is a *basic* ingredient of promoting and improving the quality of life itself. Solving problems then, is to grow not only intellectually, but emotionally, socially and likely spiritually.

To actualize human potential Feuerstein (1980) contended that mediation is the method by which adults stimulate intellectual development and promote student products whether in the form of more effective thought processes, problem solving or daily assignments. How the adult controls the context may well influence or determine the student's product. It is recognized that there are elements of context beyond educators' control, but they need to push to the limit of their ability to create, insofar as possible, a positive climate for learning. This emphasis also compels educators to push for more understanding of the processes underlying solving problems so they may provide greater assistance to their students in the development of problem solving ability: hence the impetus for further research.

Although there is some security in constants, a living organism must be able to adapt to change. Universal knowledge undergoes expansion of a spiral nature (Bloom, 1956). Perkins (1986a) submitted that knowledge is designed or invented, therefore malleable. Ideas remain continuously open to restructuring in light of new discovery. His caution against allowing the stagnation of information is a reiteration of

Guilford, who suggested that "any idea completely understood is old" (quoted by Joyce Juntune, personal communication, 1987).

Lipman (Lipman, Sharp, & Oscanyan, 1984) through his invention, The Philosophy for Children program, invited fourth-graders to discuss the distinction between discovery and invention. He favored creation of a *community of inquiry* where all participants play an active role in their mutual growth. It is in the classroom, through research into the problem solving processes of students, that truth about a system may be discovered. The interdependence between problem, solver and context is activated through problem solving.

Summary

A problem's definition is dependent upon the context in which it occurs, and in part, upon and the perceptions of the solver. Adults can influence the learning climate and also can mediate problem solving skill development. Contexts are shaped by, and in turn shape, the solver. This has impact upon the solver's perception and quality of life.

PROBLEM SOLVING

Problems surround learners the way the atmosphere envelops the planet. And like meteorologists, educational researchers are continually trying to refine their understanding of the complex interrelationships that occur as multi-faceted entities meet. Learning and problem solving phenomena provide compelling fodder for investigation on both a global and a personal level.

Just as a problem exists along a continuum of complexity so does the process of solving it. Viewed this way, people solve multitudes of problems daily, yet are often unaware of having done so. Unless the problem looms large enough to cause some discernible

discomfort, it seems not to warrant examination in much detail. Yet attention to problems occupies much of a person's day and subsequently conscious or unconscious thought.

Bransford and Stein (1984) emphasized the influence problem solving exerts on everyday life, albeit much of that influence is taken for granted. They presented a perspective which could be considered a forerunner and facet of Perkins' concept of knowledge as design (1986a) when they suggested a problem-solving purpose behind design, invention and innovation. Bransford and Stein (1984, p.2) contended that

> . . . the world in which we live is, to a very large extent, our creation. Houses, laws, furniture, vehicles, schools, scientific theories, and books are just a few examples of things devised by humans. It is noteworthy that each of these creations or inventions was designed to solve various problems.

Bransford and Stein (1984) summarized, "the solution to a problem involves getting from one situation to another" (p.3). Although this simplification describes what appears to be a somewhat straightforward process of working toward a destination, problem solving is generally proving itself to be a more complex journey than it initially seemed.

Processes

Several theorists have built upon proposed models of the problem solving process (Osborn, 1953; Parnes, 1985; Treffinger & Isaksen, 1992). To facilitate and focus discussion, Treffinger proposed a useful distinction. He referred to the conscious and specific use of strategies and adherence to the procedures outlined in the Creative Problem Solving process model as "CPS" and all the other forms of creative approaches to problem solving that occur in everyday life as "cps" (personal communication, 1992). Thus, when an individual is using a structure or model to systematically solve a problem, he is using CPS, while the common solutions to all his other daily problems is considered cps problem solving. Used as a basis for comparison, this could become a structure for describing attributes of the students' problem solving process. The development of the student research task could be considered as following the general steps of CPS, while the

emerging problems might reflect elements of cps and act as referents for the entire process observed during this study.

This suggests a need to define the phases of the problem solving process. The term, *phases* is borrowed from meaningful learning theory (Shuell, 1990) and was selected for two reasons. The first arises from the distinction drawn by Karmiloff-Smith (1984) that stages are sequential and irreversible, while phases are fluid and can be recursive depending upon the situation. The second is based upon the strong connection between learning and the personal growth which occurs from the activity of problem solving.

Essentially the problem solving models all seem to follow the same general steps formulated by Polya in 1957 (Feldhusen, Van Tassel-Baska & Seeley, 1989, chap. 17). Although posited decades ago these steps are still reflected in current models. (Eberle & Stanish, 1980; Parnes, 1981; Treffinger & Isaksen, 1992).

Broadly speaking, Polya's (1957) steps include:

1. Understand the problem.
2. Devise a plan.
3. Carry out the plan.
4. Look back.

Each of these steps can be complex and interrelated and may also be described through the events that either precede or stem from it. This ongoing process raises questions about when problem solving begins and ends. Like learning, problem solving begins at birth and continues throughout life, but can be temporarily isolated for examination relative to a particular set of stimuli and responses. Biggs (1991, p.37) referred to a three part model of learning described as a "chain of events". He continued to explain that his model

> . . . represents an integrated system with three main components: presage, process, and product . . . . Presage factors exist prior to learning, and are of two kinds: those pertaining to the student and those pertaining to the teaching context. Students bring to the classroom relatively stable, learning-related characteristics; abilities, expectations and motivations for learning, conceptions of what learning is, prior knowledge, and the like.

> The teaching context contains the superstructure set by the teacher and the institution: the course structure, curriculum content, and methods of teaching and assessment. This context, apart from its cognitive aspects, also generates a "climate" for learning, which, whether "cold" or "warm" has important motivational consequences.

Where a particular problem enters and exits the timeline depends upon many of these same factors, and the processes relative to problem solving are interactive and cumulative. They encompass cognitive operations, such as metacognition; attitudinal factors such as "self-talk" (Tice & Kuhn, 1981); and social skills including those affiliated with communication. Wheatley (1989) submitted that when"students are engaged in problem-centered learning, they are essentially building their intellectual world" (Feldhusen, Van Tassel-Baska & Seeley, 1989, p. 265).

Skills

If Polya's steps were to be placed upon a number line with "understanding the problem" considered to be the first step or point number one, it might be logical to expect there are likewise an infinite number of fractional steps between *zero* and *one* in the problem solving process. Feldhusen and Treffinger (1985) developed a model of problem solving which closely parallells Polya's model, yet draws attention to this concept of preparatory steps. The similarity of the two models could be noted by assuming that wrestling with the problem is integral to understanding the problem before embarking upon solution. Feldhusen and Treffinger's model reconceptualizes and expands upon Polya's by inserting the components: problem generation, clarification, and identification prior to: idea finding, synthesis of a solution and implementation.

Problem solving is a systemic process. It is composed of many parts which interact in a multitude of ways. *The whole is greater than the sum of its parts* is a commonly accepted expression to explain this type of dynamic mosaic. When many aspects are interacting, it is difficult to represent the contribution of any facet in isolation because of the fluid and elastic nature of the situation. Each contribution is dependent upon its interaction with the other parts for its transformation from the state of *potential energy* to thework it is destined

to accomplish. Yet each plays a role in the evolution and effective functioning of the system.

Educators are attempting to help students learn to solve problems effectively, but the fields of learning and problem solving are very broad and interrelated. In order to prepare teachers for this task, the fields need to be understood more clearly than they are at present. Moreover, each aspect to be studied must be examined within the context in which it functions.

Summary

Educational theorists have posited similar generalizations about learning, thinking and problem solving with the greatest difference occurring within the distinctions between the phases in the processes. Interaction of a learner with a problem can be generalized to some extent, but the construct presents intricate features for different kinds of problems and the aspects of the problem solving process varies with them. As well, evidence is illuminating some attributes and abilities of the problem solver which are required to meet the demands of the problems in their world. The continual interplay of these complex structures forms the basis for this study. The related issues and concepts fill volumes of current research journals and texts, but it is how each of the structures functions relative to the others that makes the problem solving process dynamic and in need of further study.

THE ROLE OF INSTRUCTION AND SUPPORT

Problem solving skills instruction

It was stated earlier that context plays a role in determining how the solver interacts with the problem and embarks upon solution. Instruction in thinking skills and the CPS model have been shown to play a significant role in developing students' problem solving process skills (Crammond, Martin & Shaw, 1990; Perkins, 1986b; Perkins &Salomon, 1988).

Even the potential of gifted and talented students remains relatively untapped until encouraged by instruction. Ludlow and Woodrum (1982) found that the group of gifted students in their study did not automatically employ more sophisticated problem solving strategies. They hypothesized that this might have been due to the gifted subjects not having been previously exposed to a differentiated curriculum aimed at stimulating their presumably greater potential. Gallagher (1985, p. 265) submitted that

> . . . the ability to generate new information through the internal processing of available information is one of the most impressive and valuable skills of mankind. The gifted child can generate such new information much faster and at a greater rate of complexity than the average student of the same age. One major task for educators is to enhance these problem-solving and creative-thinking skills of gifted students through the educational program.

The role of instruction becomes pivotal. Instruction should be aimed at empowering students to make wise decisions. Although the term,*wise*, seems value-laden, it is this researcher's contention that instructors assist students to develop their own definitions of the term and apply is as a criterion for their own decisions.

Part of helping students to develop effective problem solving skill is timing. This could be considered a vital element of instruction relating to Feuerstein's (1980) concept of mediation. Teachers should find out what the students' abilities and plans are before imposing a structure prematurely, or abandoning students who need guidance from adults. It is possible to under- or overestimate students' abilities to deal with ambiguity or make decisions. If this happens, early opportunities to develop as independent problem solvers may be wasted.

Another element which directly impacts the effectiveness of instruction is the learner's stage of self-directedness. Grow (1991) investigated this aspect of learning. He compared, in order of the greatest match, the stages of dependent, interested, involved and self-directed learners with the teaching styles of Authority/coach, Motivator/guide, Facilitator, and Consultant/delegator. He found that when there is a mismatch between learning style and teaching style, the greatest problems occur.

Also, if students are not encouraged to be tentative with knowledge they may be disadvantaged in concept formation and tolerance for ambiguity is diminished. For example, when students are first being taught regrouping in mathematics, even if they are using manipulatives, they are often told that a column can hold no more than nine units. If they add a tenth, they must form a group and move it to the *tens column*.. This adding procedure is repeated until the students can perform the action habitually. But this is the kind of teaching that limits thinking in two directions and leads students away from being able to regroup fluidly when the problem requires it. As an alternative, if the teacher were to introduce tentativeness along with grouping as a concept, students would likely be able to make the small jump to regrouping more smoothly. Words such as, "usually, for now, etc.," keep the door open for new information (Covington, et al. 1972) and accomplish both goals in a more coordinated fashion. Thus the student learns to count numbers both forwards and backwards, creating larger groups or breaking existing groups to more fully appreciate that number lines travel in more than one direction. In this way the seeds of understanding numeration have been planted and more sophisticated mathematical knowledge may develop in time, without other teachers having to "deprogram" children's rigid and limited elementary thinking.

Then, as the problems faced by students move toward becoming more ill-structured, or those structured with some productive thinking required, students are not expected to leap the chasm with intuition as their only strategy. Organization and processes should be taught as interactive, rather than linear, models. This is particularly appropriate for gifted students who may be more able to deal with abstractions and interrelationships.

It is tempting to suggest that very young children cannot deal with abstractions and prefer to work with only black and white ideas instead of issues in shades of grey, but the researcher suspects that this would be an underestimation of their ability. Even young children need to have speculative thinking modelled so they may develop the syntactical structures and language which will later enable them to deal with tentativeness. Concepts

such as "maybe" and "might" will not develop if children have not had the chance to explore them first (Costa, 1984; Feuerstein, 1980). Teachers can go a long way toward providing an environment rich in stimulation and possibilities.

Treffinger's newest work stressed the value of working through this linking phase. He suggested that all too often teachers expect students to skip from tool acquisition to real world application of skills and are surprised when some children cannot make the jump from one level to the next (D. Treffinger, personal communication, December, 1992).

A particularly disturbing finding is that these suggestions are by no means new, totally original nor are they unique. Bloom (1956, p. 167) submitted,

> Often criticism is directed against the over-use of objective-type examinations on the grounds that these forms do not force the student to produce original ideas or to organize them. Whether or not this argument is defensible is a matter to be decided by further study; in any case, however, lack of appropriate practice must surely account for many shortcomings in the development of synthesis abilities.

Moreover, preparing for appropriate practice by developing organizational or creative skills, through moving from tool acquisition to the application of problem solving skills, to solving a real world problem, does not often seem to be part of instruction. Sometimes the tool skills are taught in isolation, sometimes the creative problem solving process is introduced, but teaching for the transfer of skills seems to be overlooked. It is disappointing that, over the last four decades, there is little evidence supporting the application of even the most basic of these suggestions in classrooms. Bloom's levels are recited as a catechism for gifted students, but mere recitation of these levels is insufficient for many teachers to sense the value of such a direction for learning. Some teachers feel the taxonomy has been flogged to death. This researcher has seen eyes roll at the mere mention of Bloom. It is sad that the educational objectives Bloom described have not, even yet, been really achieved. It may be that educators have not defined or formulated the problem clearly enough to invite its solution. Perhaps through more attention and aptly defined research problems, answers may be forthcoming.

Teaching for transfer

Students need progressively taxing problem solving training and opportunities to move dimensionally forward to finding, formulating and approaching increasingly ill-structured problems.

Crammond, Martin and Shaw (1990) also found there was greater generalizability in groups who had been trained to transfer learning. Their investigation centered around gifted middle-school students and compared groups trained in CPS and groups with transfer strategies infused. Both of these were compared against a control group. Their work strongly called for the importance of teaching for transfer and utilizing inclusion of real world problems in students' programming as a vehicle to achieve that aim.

Montague (1991) used clinical interview as a means to investigate strategies employed by gifted and learning-disabled middle-school students presented with mathematical word problems. She emphasized their ability to select and deploy task-appropriate cognitive strategies. Student-selected tactics led to understanding, representing and solving problems. These skills required metacognitive knowledge and self-awareness about performance, and were found to be prerequisite for higher-level learning and problem solving.

Montague's descriptions of the cognitive attributes of good problem solvers supported the concepts of the use of working memory and meta-memory as well as metacognitive control over strategy use. Her work supported Coleman and Shore (1991) by agreeing that proceduralizing problem solving leads to more sophisticated problem solving skill. Montague also cited Lester (1980) and called this a "rich sequence" of problem representations (Montague, 1991, p. 395). Current brain research supports the value of proceduralizing and sequencing in effective information processing (Sylwester, personal communication, December, 1992).

Several researchers have investigated the functions of information processing and memory. Phye (1990) examined inductive problem solving to show how people use knowledge to solve problems. He identified "induced schemata as a part of the architectural basis for cognitive transfer" (p.826). Zentall (1990) looked into adolescent problem solving and also stressed the instructional implications for developing problem solving strategies. Weed, Ryan and Day (1990) explored meta-memory and motivational factors influencing performance. Their findings, though neither specifically aimed at gifted nor problem solving, supported the notion of strategy instruction. This was in line with the recommendations made by many researchers regarding the influence and importance of strategy instruction and conditions which foster strategy use. (Feuerstein, 1980; Frederiksen, 1984; Perkins,1986b; Perkins and Salomon, 1988; Schuell, 1990; Sternberg, 1984, 1985b; Zentall, 1990). Perkins and Salomon (1988) stressed the need for teaching for transfer if students are to be expected to perform such skills. Some students intuitively transfer learning, but this should not be left to chance, nor should it be the only strategy available to a student.

Teachers may sense that honoring intuition and utilizing it as a type of instructional strategy is useful, but more proof of its effectiveness is needed if it is going to be acceptable to the tax-paying public. Trust in intuition is healthful, and supported by many, especially in the field of creative thinking (Clark, 1979; de Bono, 1985; Torrance, 1972), but large numbers of teachers and most parents and school boards prefer more concrete, means-end, cause-effect evidence before they will sanction such a move away from their perception of basic education. Ironically, as Costa (1984) suggested, these and other thinking processes are more basic than reading, writing and arithmetic.

Training teachers to use process skills

There is general agreement that process skills need to be taught explicitly, practised over time and integrated into curricular areas (Covington et al. 1972; de Bono, 1985; Dirkes, 1985; Kaplan, 1985; Mulcahy et al., 1987; Nardi & Wales, 1985; Parnes, 1981, 1985; Perkins, 1986b). However these proposals do not provide the empirical proof that they

work. Nor do they always offer to everyday practitioners simply-explained reasons why they are necessary. Furthermore, they do not offer specific examples of how to get "from here to there". Teachers are not often given clear examples of how to explicitly design instructional opportunities which are likely to pay off with growth. Teachers may have trouble explaining, in the form of grades on report cards, the evidence of processes employed. More research and teacher training is necessary if these problems are to be solved.

Problem solving programs

There are many programs available offering assistance in areas of thinking and problem solving, in terms of teacher planning and response behaviors, which seem to demystify the fog that surrounds teaching and learning through process instruction. Exemplars are offered by notable scholars and practitioners (Costa, 1985a; Eberle & Stanish, 1980; Ellis, 1987; Juntune,1990; Lipman et al., 1984; Mulcahy et al., 1987; Paul et al., 1989; Perkins, 1981, 1986a; Treffinger & Isaksen, 1992). A gap exists between theory and practice along the journey from instruction to transfer of learning. The public hue and cry remains product oriented. In spite of all the attention problem solving process instruction receives students are still leaving schools unable to use it solve real problems. This is borne out frequently by examples such as Kaplan's student stuck on the curb. Treffinger and Isaksen (1992) supported the need for instruction through the phases and strove to bridge this gap with their three levels of problem solving and thinking skills instruction.

Frederiksen (1984) cited several studies into cognitive theory, problem solving and instruction. The systemic interrelationships between these and learning deserve much consideration. He supported "teaching generalized procedures for problem solving in new situations" (p. 363), but was careful to draw important distinctions critical to the effective implementation of this type of teaching. First, he underscored the difference between well-structured problems, usually found in problem solving instruction, and ill-structured problems usually found in real life, as supported by Sternberg (1985b). If teachers do not

help students actually solve real problems, the programs are not accomplishing their objectives.

Activating processing—memory by design

Information processing is at the heart of this system. Frederiksen (1984) explained information processing as the mechanism whereby the brain makes use of the stimuli it receives. Frederiksen stressed the role of memory as the handler of stimuli, thus a key to the processing of information. He suggested most cognitive psychologists agree upon at least three main categories of memory: a sensory buffer, long-term memory and working memory.

The sensory buffer is the receiver of a stimulus and serves as an initial organizer. After a stimulus is registered it is maintained long enough for the buffer to recognize, classify, ignore or store it as required. Sylwester (personal communication, 1983) also referred to this type of process. Sylwester's work described this construct from a physiological standpoint. Sylwester explained that processing occurs in the chemical reactions of the brain. He used the analogy of a mail sorter to explain how the brain takes in pieces of information and sends them to an appropriate destination.

Long-term memory, (LTM), is believed to be almost limitless and retains knowledge and skills, both psychomotor and conceptual, as isolated items or groups of related items. "Information is stored in the form of *nodes*, [italics in text] which are interrelated in complex ways through learning" Frederiksen (1984, p.364). An exciting feature of LTM is that it does not rely solely upon information received. It can reorganize and derive meaning beyond what was explicitly recorded. This allows the learner to attentively store information as desired, or group related items into procedures or interconnect and activate networks of nodes automatically. This has strong bearing upon the notion that creative problem solving skills build into habits and expertise.

The working memory is the mental desktop with access to the *files* of LTM and the stimuli of the sensory buffer. However, it has an attention capacity limitation of only about seven items. Once this limit is reached, the brain must reorganize, cluster or group the information. An example is the telephone number. Dividing the sequence into two groups of numbers is easier for the brain to retain than one long string of seven numbers. (A. L. Costa, personal communication, 1988).

The concept of part-whole relationship explains the way a learner files an item of information. This could be considered a part which influences the whole schema that is formed. Teachers who help students to help themselves through teaching for transfer and problem solving, bring out long range changes to the students' learning. This concept is not new. For example, Torrance and Myers (1962, p. 2) have pushed for the use of research as a teaching tool for decades. They believed,

> . . . that if gifted children can be taught these concepts and skills at an early age that they will have available some very powerful tools to aid them in their learning and thinking from that time onward. This should make learning more exciting and the search for "truth" more rewarding.

Richard Skemp was also concerned with teaching for transfer and the schematic learning acquired and built by students. He believed the school has to establish an environment where "intelligent learning can take place" (Sfard, 1990, p.51).

Habits of mind

It is believed that information processing can be controlled or automatic. Problems which have been solved so frequently that they have become habit, cease to stimulate conscious problem solving. Sequences of knowledge can be activated under the direct attention of the learner or trained and practised to an almost habitual reaction requiring very little attention. This change permits the working memory to allow for more complex operations. Automaticity can be observed as learners become more familiar and adept at a new task. A person learning to dance might count beats, recite steps and mechanistically perform a

dance until the sequence becomes practised and smooth. Once committed to memory, all that is needed for performance is to be stimulated by a song's rhythm; freeing the dancer to respond to more interesting challenges or modifications brought about by musical arrangement, dance floor conditions or an unfamiliar partner.

The effectiveness with which these three types of memory function in relation to one another are the crux of the learner's effectiveness for mobilizing the forces of learning experiences. Herein lies the connecting and catalysing nucleus for the interrelationships among teaching, learning and facilitating. The ability to separate a meaningful signal from background noise is critical to knowing what to notice and what to disregard. Teachers can assist students in formulating judgments about their internal filing systems (G. L. Mancini, personal communication, 1992). When they are receiving stimuli in the form of curricular content, students can be guided in efficient methods of handling the information. Teachers must be careful not to control the students' thinking, but help them to help themselves in deciding upon what they need and how they are going to store it.

Since the effectiveness of automaticity is related to the initial organization of information, teaching plays a vital role in assisting students to organize information effectively in the first place. A messy filing system makes it difficult to retrieve necessary files and more time and energy may be wasted on doing a job than the job requires.

If teachers do not teach with information processing in mind, and more importantly, in the students' minds, too much information is stored inefficiently as discreet bits and working memory is kept busy with unrelated snips of detail. The systemic potential of learning is squandered when LTM is wasted on disorganized fact accumulations rather than efficient, accessible and usable collections. The whole picture is in danger of being missed by the obstruction caused by the mess of the parts. As well, important cues and clues for

facilitating automaticity may be overlooked. Feuerstein (1980) called this, "an episodic grasp of reality" and treated it as a cognitive deficit in need of mediation.

The trap of habits of mind

Conversely, automaticity is not the only answer. There are also drawbacks to automaticity of which students need to be made aware. Pattern recognition is an essential skill and is often characteristic of gifted learners. But it can be over-applied and used to blind the learner to new possibilities. In 1843, Carlyle said, "Fire is the best of servants; but what a master!", the same might be said for habits in today's changing society. Covington et al. (1972) strongly supported keeping an open mind and constantly being receptive to new information. Gifted learners who have not been wrong often enough, may come to take their superior knowledge for granted. This may in fact, reduce their acquisition of new data which might precipitate restructuring of a generalization or expanding upon a concept. It is very difficult for someone who knows it all to learn anything new. Gifted adolescents who have not been encouraged to question even their own knowledge have been underserved. Sylwester discussed the need for contrast to stimulate the brain since people "instantly habituate" (Sylwester, personal communication, December, 1992). Students need to find contrasts and contradictions present within their own thinking (Sylwester, 1990).

Fully functioning self

Helping students to question and organize their thinking is not to be confused with giving them a pre-existing organization. Since no two minds function exactly alike, (Buzan, personal communication, 1988) students must be encouraged to actively construct their own internal organizations. Kelly (1962) described fully functioning persons as those who are cast in creative roles because they see themselves in the process of becoming. Many researchers and theorists advocated stimulating students to build connections when learning and to share these with each other (Costa, 1984; Kaplan, 1985; Perkins, 1986a; Sylwester, 1990; Wasserman,1987). Products must be expected to exhibit a creative, constructive nature, even if novel only to a particular student.

Educators do not help when they solve students' problems for them. Instead, teachers should lead students to the brink of new knowledge. This researcher suggests that the use of teachable moments could be combined with content and CPS skills, and mediated through metacognition to allow students to capitalize upon the learning opportunities life presents. It blends the world of school with the realities of the student. They become mutually enhancing, ignited by the teacher's passion for learning. Penzias (1989) was aware of this when he stated that although, "Michelangelo's work inspired countless artists, he couldn't instruct others to create . . . while theory helps us appreciate great works of art, the mechanistic application of its rules rarely leads to masterpieces." (Penzias, 1989, p.31) Students must be allowed to solve their own problems in their own way. This does not imply they are to be without assistance. Being abandoned to work on problems alone does little to mediate, generalize or extend experience. This can be accomplished through guided metacognitive reflection, especially with groups of gifted learners. Learning is often more successful in a social context. Sternberg (1985b) reminded teachers that real world problems are often solved in groups.

Metacognition as a means-ends tool

This researcher believes assisting with initial organization of information to be another major function of the role of metacognition during instruction. It serves to assist learners to reorganize and go beyond information parts to form inferential wholes open to scrutiny. It alerts learners to their control over their own intellectual filing systems. This enables them to actively design efficient access routes to the applications of instructed skills and procedures. These include productive thinking tools and strategies or creative problem solving, inquiry or decision making processes (de Bono, 1985; Dirkes, 1985; Dorman & Edidin, 1989; Ellis, 1985; Minteer, 1953; Parnes, 1981; Sylwester, 1990; Treffinger & Isaksen, 1992).

Gifted students can and should be encouraged to recognize the part-whole relationship of knowledge, skills and application to facilitate automaticity of processes. They need the

available working memory space for the greater uses of complex thinking and problem solving. Van Tassel-Baska et al. (1988, p. 386) stressed,

> Problem-centered learning is particularly appropriate for gifted students. They have a much greater capacity to sense problems, note discrepancies, and detect ambiguity. Since the gifted are generally more curious and have the ability to follow through, the classroom should be a place where they are free to pursue the questions they raise. Otherwise, potential learning will turn to disillusionment and frustration.

The pieces fit together

Renzulli (1976) reminded educators that process is the path, rather than the goal, of learning. It is the means to an education, not education itself. Thus content for this initial training may need to make use of well-defined problems as vehicles for acquisition of the tools necessary for the problem solving process. The working memory can then be freed to divert its attention to learning a procedure and designing networks for access and transfer.

Very early in the training there needs to be the expectation of, and teaching for, transfer and the opportunity to exercise the new skill on a simple but ill-structured problem. Without this built-in transfer concept, access to the process during novel applications or ill-structured problems seems to be diminished. Crammond, Martin and Shaw (1990) submitted that students who have been taught with transfer as a goal are the ones who will apply the processes.

Renzulli (1977) suggested his model of Type III enrichment as a way for achieving this aim. He recommended encouraging a student to pursue activities whereby the learner becomes "an actual investigator of a real problem or topic by using appropriate methods of inquiry" (p.29). This type of activity promotes process training by having it take place within a context where transfer is not only natural but necessary. Students have to learn several process skills in order to conduct their investigation. Thus the part-whole relationship is active. There is a dynamic interplay of temporary emphasis on acquisition of a skill and its immediate application to a problem situation. Implicit in this method is the

assumption that metacognitive guidance is continuous and ongoing to guide, debrief and extend student learning (Mulcahy et al., 1987). Metacognition promotes effective and additional internal organization, generalization and preparation for transfer.

Frederiksen (1984) summarized, "Thus it is possible that problem-solving capacity can be greatly increased by learning to use automatic processing for the more routine elements of an activity, making available controlled-processing resources for the novel aspects of problem solving" (p. 365). Coleman and Shore (1991) supported this notion. The experts and high performers they investigated applied procedural working memory to problems which enabled them to outperform their less-effectively organized counterparts. It would seem logical to assume this phenomenon might also apply to students with other types of needs.

Zentall (1990) conducted a study of fact retrieval automatization and math problem solving of adolescents. Although there were differences between Attention Deficit Disordered, (ADD) and Learning Disabled, (LD) children and the normal control group on problems of moderate attentional demand, he also found that there were no clear-cut differences between students working with a"difficult attentional-load problem type" (p. 864) and proposed that the results might be attributed to the fact that these problems were difficult for the normal control group as well. He suggested that current instructional methods are not meeting the needs brought about due to the attentional characteristics of the ADD and LD children. Although he did not go so far as to suggest it, his results spoke to the possibility that effective strategy organization skills may well be of use to the regular student population too. If it can be assumed that effective use of working memory is what is needed for these more complex problems, it seems fair to hypothesize that students of many differing ability levels would benefit from instruction with an applied process base. It is likely advantageous then to help students develop automatization skills and procedures.

The findings of Weed, Ryan and Day (1990) would also seem to support this view. They investigated "the process by which meta-memory and academic causal attributions relate to recall" (p. 849). They found that intelligence and belief in their own ability gave students

an initial advantage, but "these factors become less relevant with experience, whereas more general understanding of one's own memory processes, as well as of task and strategy variables, become increasingly more associated with success on related tasks" (p. 854). They suggested that meta-memory is more important for generalization and maintenance than for initial task performance. As well, they recommended instruction which encourages strategy usage through invitations to self-monitor with metacognitive guidance. This might be considered consistent with the aforementioned value placed upon the role of teachers designing instruction with strategy and metacognitive principles infused with content which might allow for smoother access and interaction between the three categories of memory.

The educator's challenge— From Teaching to T'eaching

Of actual concern to many teachers is how best to prepare students to meet this variety of undertakings. A teacher's greatest challenge is applying theory while involved with the practice of meeting the needs of individual students. Education has evolved from expecting students to fit a program to fitting the program to match the needs of students, known as developing *programming* (Treffinger, 1981). What was once teaching, that is, delivering the curriculum to the class, now has an individual focus, to help each child activate his own processing. This becomes "to-eaching" the curriculum, with its contracted form: "t'eaching". Whether it is possible to "t'each" effective problem solving in schools remains a question for further study.

Summary

Instruction in the use of metacognitive skills applied to information processing is seen as crucial for the effective utilization of memory. This skill enables students to control the evolution of problem solving ability and quite probably allows for movement along the problem solving continuum as students increase their repertoire of problem solving strategies.

Unanswered Questions

In spite of the abundance of literature in the field of problem solving, there are still many stated needs for further investigation. In particular, there was limited empirical data on ill-structured problems, gifted students' problem solving processes, and even less which combined all the elements.

Each of the research studies available contributed to some facet of this investigation, but all of the researchers clearly recognized the need to continue the pursuit. Frederiksen (1984, p. 398) lamented, "so far, there have been few investigations in classroom settings concerned with the application of cognitive theory to instruction" in particular, problem solving training. Hoover and Feldhusen (1990), were concerned about the absence of studies involving ill-structured problems. They concluded, "This study was an initial exploration of a many-faceted concept, and it does provide direction for future research . . . . In what little research has been conducted, investigators have not used realistic problem situations"(p.847). Crammond et al. (1990) studied CPS and transfer, but the methodology did not employ ill-structured problems.

Educators have learned a great deal about problem solving in the last few years and one thing has become abundantly clear. To these beginning questions there are no simple answers. There is still much to be learned before they can be answered with any certainty. It begs exploration of additional facets to the puzzle.

SUMMARY

The literature reviewed by this researcher, in preparation for describing the process a group of gifted students used when solving problems for which there had been no predetermined answer, presented some interesting connections. At first glance, Polya's (1957) set of theoretical stages of problem solving seemed to be a relatively straightforward process.

Investigation into the field of problem solving uncovered a much more complex set of interrelationships, and convinced the researcher of the need for further investigating the construct through this type of study.

The findings of this literature review suggest that several elements need to be part of educational programming if it is to accomplish its "mission to impart knowledge and to teach cognitive skills. One of the most important cognitive skills is no doubt problem-solving ability"(Frederiksen, 1984, p. 363). The main points of this review are summarized through the following statements:

- there are differences among problems, in complexity, structure and consequence,
- the context of a problem influences its definition,
- good problem solvers exhibit similar characteristics of intelligent behavior, such as metacognition and prediction of consequences,
- giftedness does not guarantee good problem solving abilities,
- there must be opportunities for students to work on many problems reflecting all facets of the continuum between well- and ill-structured problems,
- students must be given opportunities to practise finding and formulating real problems,
- problem solving is an interactive process relating to the problem, context and solver,
- instruction must be process oriented, with attention focused upon transfer, i.e. where and when to apply the processes,
- content must be regarded as a vehicle for exercising cognitive skills,
- problem solving and learning are shaped by many factors, including those such as motivation, memory and perception,
- there needs to be more research into students working on ill-structured problems, and
- it is possible to gather empirical evidence in this area.

The slippery, interrelated categorizations of thinking skills, metacognition, executive processes, decision making, creativity and independent learning lend themselves to the development of the construct of problem solving. These, coupled with student ability and personal state are all variables, along with conditions of instruction that go beyond the direct control of educators. Arguably some are in varying degrees of control within the learner himself.

CHAPTER THREE
RESEARCH DESIGN

Chapter overview

Using a market research project as a vehicle, this descriptive study was designed to enable the researcher to observe high ability, middle-school students involved in solving real world problems within a school setting. The researcher hoped to uncover elements of the problem solving process used by able learners as they approached and surmounted the problems embedded within the project of their design. The goal, however, was to describe the process observed as students worked on *any* problems stemming from work on the project.

This chapter outlines both the rationale for, and the method, of data collection employed by the researcher in establishing and working on the research task. It charts the researcher's work facilitating students' research while simultaneously observing the problem solving process they engaged for their project. The context for both levels of the study will be explained through descriptions of the task, the student subjects, their school setting, their classroom teacher, the game and the researcher's role and involvement with students.

Design Rationale

The decision to employ a vehicle through which to evoke problems in addition to interviewing students about how they solve problems was made for three main reasons. First, school is based upon student activity. However, this activity is usually very structured, and the researcher wanted the opportunity to observe students working on an assignment involving a less-structured problem. In order to incorporate this element of ill-structured problem solving, the researcher had to find a way to engineer such a situation. Another facet of the project was that the problem was intended to be real to the students, so the ill-structured situation also needed to invite student commitment.

The second main consideration was that the researcher proposed combining student self-reflection with the observations of others to create a wholistic and realistic collection of data. Students' views of themselves solving problems might be blurred by the abstract nature of the interview questions, the changing contexts in which problems occur and by their own perceptions of themselves. Moreover, the researcher's perceptions of the observations would be a result of her experiences, so the design was intended to balance, as fairly as possible, the perspectives of these different lenses for interpreting data.

Third, the age of the students also caused the researcher to be cautious in developing a research method. It was intended that the researcher would observe the students as they encountered real problems. In order to remain within the parameters of time and student experience, it was necessary that the problems students would encounter could pose enough challenge to be considered real, while at the same time be manageable so as not to subject the students to undue stress. Treffinger insisted that real problems must drive students to action, but be within their sphere of influence (D. Treffinger, personal communication, December, 1992). If a problem is too global, or beyond the child's potential to define, by Treffinger's definition, it ceases to be real to the student. Treffinger used the example of world pollution as too large a problem for a student, but how to alert some people to the dangers of pollution, or how to encourage peers to recycle would be within the student's realm of control. Gifted students may worry about the problems of the world, but they need to be able to bring structure to problems in order to make them manageable enough to attempt solution.

Original research offers many of the characteristics of an ill-structured, real world problem. However, a concrete product was also deemed necessary to effect satisfactory closure to both the students' project and the process description. The market research selected for this study seemed to be both *challenging* because of its open-endedness, and *manageable* since its principles shared many of the attributes of real world problem solving. While simultaneously offering students the opportunity to explore problems and play with ideas ideas, the volunteers could bring the task to conclusion through creation of a somewhat

tangible product within the familiar structure of a research project. The advantages and disadvantages of this research design will be discussed in chapter five.

STRUCTURE OF THE STUDY

The researcher made observations while working with academically talented students conducting original market research testing claims that a boardgame increased creativity. The researcher was investigating the problem solving process of the students as they encountered real world problems associated with their task. Student oral, log and questionnaire response comments; interviews with parents and the classroom teacher complemented the researcher's field notes. The data were analyzed and the interpretations formed a description of the process observed.

In order to establish a realistic real world problem solving situation the researcher needed to take the following criteria into account when selecting a task. The project would:

- be a problem of enough significance, interest and concern to the students to merit their time and attention. When a challenge becomes *real* to students it should evoke their problem solving abilities,
- represent a reasonable facsimile of the students' lives by occurring within a similar context,
- pose challenges for students through embedded problems possessing the characteristics of Sternberg's (1985b) description of real world problems,
- be manageable within the parameters of student ability, and time allotment for the study, and
- arise from a context which would meet the ethical standards set by the University.

The researcher anticipated the elements of this situation would be similar to the stages of the creative problem solving process. This process is based on the work of Parnes (1981). It has been influenced by Osborn (1953) and modified by Eberle and Stanish (1980). Frequently taught in schools, it consists of six basic steps:

i) sensing problems and challenges, often referred to as "mess finding",
ii) fact finding,
iii) problem finding,
iv) idea finding,
v) solution finding, and
vi) acceptance finding.

The researcher expected that the problems encountered by the students would present characteristics similar to those of real problems described by Sternberg (1985b). They were likely to be context-dependent and lacking structure. The students would probably not be clear as to what information they would need to solve their problems nor would they likely know where to find whatever information they required. The researcher anticipated that the students would present evidence of some of the characteristics of intelligent behavior (Costa, 1989) such as striving for precision, accuracy, tolerance for ambiguity, with-holding judgment, communication and metacognition.

The researcher suspected that when real world problem attributes are approached through intelligent behavior, the result would likely be progress, but not necessarily in the linear, hierarchical fashion neatly laid out in process instruction manuals.

Since the market research task provided a vehicle for the students to come into contact with real world problems, the researcher considered the possibility that additional problems might arise. Real world problems can occur in many dimensions and the researcher was interested in observing the embedded and ensuing problems as well as the problems specifically associated with students conducting market research. The researcher expected

the process to follow a somewhat recursive path which could include setbacks as well as successes.

Because of the possibility of emerging problems affecting the students personally, priority consideration was given to the needs and rights of students. Care was taken that the project would not put them in any position of disadvantage, and this was reflected in the permission obtained to conduct research within the district. Consent forms describing the project were sent home with students, and were to be signed jointly with parents. The researcher provided a written synopsis of the study with the permission form to explain the parameters and intentions of the project. Students were given the opportunity of participating as spectators, subjects or researchers. Participation was strictly voluntary but it was hoped that several students would be sufficiently interested so that observations of problem solving behavior could be documented.

The following sections will describe the context in which problem solving behavior was observed. The descriptions provided will give the reader a picture of the situation from which to interpret the data collected.

Setting

A large, urban junior high school in an affluent neighborhood was selected as the setting for the study. A school-developed brochure described the site as "a comprehensive junior high school which maintains high standards for academic excellence while fostering a well-rounded education." The school population of approximately 550 students in attendance had been rising steadily for several years. The school prided itself on its strong academic standing. The students scored consistently well above average on district achievement tests. The upper middle class community acknowledged the school's reputation for high achievement scores and student awards.

Parental support for, and involvement in, the students' education was strong. The school staff was aware of the importance of the role of the home in effective schooling and invited

input. Parental and student perspectives were considered when determining policy and practice.

The school offered a variety of programs. It was a district center for Adaptation, English as a Second Language and Academic Challenge programming. Students participated in physical education, home economics and industrial education. Options available included art, instrumental music, drama, French, outdoor education or computer studies. There were many additional opportunities in which students could become involved. These activities included: Students' Council, Peer Support, special events, intramurals and clubs. There was a strong athletics program as well. Expectations of success in competition were high.

Of particular interest to this study was the portion of the school population receiving Academic Challenge programming, since it was the subset of the student body from which the participating class was selected. Students within this group had been identified as academically talented. They were so classified by virtue of meeting district eligibility criteria for the designation of Academic Challenge. Because of their recognized special-educational needs, these students were deemed to require differentiated programming of a more sophisticated and complex nature than their age-peers. An individualized educational plan was expected to be drafted for students with a special needs coding

Some researchers might include these able learners in their definition of gifted students, although use of the label had not been the practice of this particular school district. In order to serve upwards of 80 000 students, the district used its coding system for allocation of resources for programming to meet the needs of all students, and did not assign the term *gifted* to students who had met eligibility criteria for Academic Challenge.

Eligibility was determined on the basis of standardized measures of intellectual ability and academic achievement, as well as recognized strengths and needs through parent and teacher nomination. This consisted of questionnaires which requested ratings be assigned

to descriptors in order to assess recognition of characteristics such as curiosity, risk-taking, persistence, reasoning and motivation. Raw scores were entered on a composite matrix, then tabulated.

The matrix incorporated a rating scale for each of its four categories. Minimum scores for receiving points included:

- a 6-point scale for intellectual ability where students needed a measured IQ of at least 122,
- academic achievement was rated along a 4-point scale, with the 85th percentile as the first level, and
- on each of two, 3-point scales, one being for parent and the other for teacher ratings, students had to have attained raw scores of 30/60 on the questionnaires.

Students from (K-2) needed a total weighted score of at least 23/30, while older students needed a minimum of 20/30 to be considered having met eligibility criteria.

The school housed approximately 110 Academic Challenge students. The Academic Challenge students were grouped homogeneously for core subjects of language arts, social studies, mathematics, science, and health. They were integrated with all students for options. Their core subject schedule was compressed to allow time for seminars in which to delve more deeply into specific subjects at different grade levels through activities, field trips and guest speakers. The grade seven Academic Challenge seminar focus was on research and writing skills. The grade eight students experienced mathematics and social studies enrichment while the grade nine students explored language arts and science challenges.

The courses of study for all students were expected to be challenging and were based upon the provincial curriculum. The school had developed a system of "unipaks", which were prepared collections of material for student usage. The expectation was that the classroom teacher might add to, or modify the unipak somewhat to meet the individual needs of students, but would base the coursework on the contents of the package. This provided

for some degree of consistency between classes since the students took common examinations. Some students might be declared exempt from final examinations if their course average was above eighty percent.

The principal and staff had ongoing concerns about adequately challenging able students. They knew they had a successful school yet continually sought ways to improve the learning environment for all learners. The unipaks contained all the notes and information the students needed to prepare for examinations and yet the staff recognized the need to make adjustments to accommodate individual differences.

This research study presented a departure from the norm and attracted the principal's attention as another way to challenge able learners. He was supportive of the project and displayed interest in the opportunity for his students to work independently. He stated a desire to be kept abreast of progress and findings.

Class

The atmosphere of the school lent itself to the nature of this study. The researcher was presented with choices among several classes that would have been suitable for the investigation. The participating class was initially randomly selected. It consisted of twenty-two, ninth-grade Academic Challenge Language Arts students with an almost even split of male and female pupils.

Ninth-grade students of high intellectual ability were selected in hopes of capturing their metacognitive processing through logs and interviews to support observations and analyses made by the researcher. The students had differing histories and experiences with Academic Challenge programming. Some had attended elementary district centers for full-time, segregated programming, while others had experienced pull-out programming. A few had only recently been identified and joined Academic Challenge at the junior high district center. The classroom teacher felt the entire group possessed the basic skills to enable them to be successful with this undertaking.

The teacher

The teacher was not known by the researcher prior to this study. Her name was suggested by a colleague as someone who might be interested in "that sort of thing". A meeting was arranged with the teacher to describe the process. Having been approached, the teacher discussed the proposal with the researcher and embraced the opportunity for her students to apply their research skills. She commented that this was "real stuff" and therefore likely to be useful to the students. She readily agreed to allow the students to participate and was prepared to be flexible in her programming. She declined the opportunity to facilitate the students' research, preferring instead to act as an observer. It was because of the teacher's willingness to try something new that the project could take place at this site.

Although an experienced teacher, with a Master's degree in education, she herself was new to the school that year. Her assigned work load included being half-time Language Arts instructor and assistant principal. The teacher incorporated innovative ideas into her teaching strategies and encouraged her students to take risks.

The teacher had good rapport with her students, knew them well and treated them as individuals. She recognized a cultural diversity. When some students and their parents, because of religious beliefs, objected to the content of some passages in the novels prescribed in the unipaks, the teacher allowed them to select alternative novels. To accommodate differing viewpoints she consistently offered a variety of choices in reading materials as well as flexibility in discussions.

One way the teacher demonstrated her flexibility was to allow students to choose between participation in the market research task or a different assignment. Not all students volunteered to be involved in this study. All the students were involved with a curriculum unit on advertising so the market research task related to this study matched topics being discussed in class. This allowed for minimal disruption to their curriculum continuity.

While the researcher worked with part of the class, the classroom teacher involved the remainder in other activities relating to the marketing unit. The teacher visited the researcher and students during the study and held other classes with them for ongoing contact. Since she agreed to act an observer of the process, the classroom teacher was asked to keep a log to record her comments. As well as this journal she held daily discussions with the researcher. The classroom teacher was always available to analyze perceptions and would offer suggestions as to how best to deal with specific questions regarding discipline, emotional reactions or work ethic. She would verify observations and statements the researcher would make, and helped by providing additional information about a particular student as needed.

Game description

The classroom teacher requested that the whole class be introduced to "FFlow", a commercially available boardgame, which was to be the focus of the market research task. The game's architect, Michael Haynes, extended to the students an opportunity to field-test his product. Haynes wanted to ascertain whether or not, in the students' opinion, his game contributed to the development of creativity in its players. A brief description of the game should assist the reader in visualizing the students' research designs.

The game generally involves players answering a series of open-ended questions while moving triangular pieces about a game board resembling a fictitious continent. Much of the artwork resembles Polynesian-looking characters with vivid colors and clear definition contrasted with misty pastels, maze-like and oceanic images. The Wasteland territories surround dark characters, like woodcarvings, with gaping mouths.

"Weird-questions" involve "dramatic roles and strategic challenges". The player changes roles with unusual characters, explains occurrences, describes sounds or tastes, compares entities and the like. Questions range from the philosophical to the outrageous, and players may modify questions as they choose.

Recommended for two to six players or teams, ages eight to adult, the objective of the game is to be the first player to occupy the territory of "BLISS". To enter BLISS a player must successfully complete a Brainteaser, having previously successfully answered a question from every other territory excluding the Wastelands. These "Closed Questions" include explanations, deciphering codes, number puzzles and such.

Movement from one territory to the next is based on a vote from the other players as they judge whether or not they consider the answer to have been creative. The slogan on the game's box refers to it as, "The game of turning on creativity". The claims made by the architect are as follows, (Haynes, 1989, p. i)

> FFlow turns on creativity by presenting a unique social context where present skills can be used and new skills discovered. Playing FFlow releases laughter and emotional intensity which in turn increases creativity.

Because FFlow is open to a variety of procedures and levels of interpretation, players may alter its structure to suit themselves, which the architect argues is, in itself, a creative act. Haynes and his co-authors are clear, however, not to guarantee improved creative skills: (Book of Wonder, p.v)

> The state of FFlow is the experience of sinking into an effortless mental activity in which your skills are perfectly matched to the challenge. The more FFlow is experienced, the more the Player wishes to experience it . . . . Because the game of FFlow grows richer with play, the strength of this natural high becomes increasingly rich. The result is not only a state of pleasure, but, a series of creations that enrich the life of the Player and the Player's world.

There are obvious variables determined only by the players each time the game is played, such as the definition of a creative response, and the various motivations for applying ratings. There are also many aspects of the rules which could be argued on the grounds of whether or not they define or manifest creativity, the use of time limits or peer judging for example. There also exists the question of how to define and measure creative growth.

MARKET RESEARCH TASK

The task for the students was to design their own research project in order to determine whether the game, FFlow, "turns on creativity". They had the opportunity to select methodology of either a qualitative or quantitative nature. The students were to select which of the variables and aspects to use during their research projects. Most students elected to employ experimental research methods.

The age of the subjects compelled the researcher to set parameters on the project so that the students would be able to arrive at some form of closure while gaining a greater appreciation for the spiral nature of knowledge construction. These parameters included bringing the project to conclusion within the time limits and, for those choosing to design projects of a more experimental basis, working on one set of variables so as to keep the students' research task manageable and appropriate to their skill level.

While the game was expected to enhance creativity, the students' project was also expected to yield information about the process employed by students doing their own problem formulating. Although the researcher was observing the creative problem solving process evoked by the nature of the task, she was interested in describing *all* levels of problem solving observed as the students became engaged in their market research.

To stimulate interest in the project, the classroom teacher agreed to introduce the task to the whole class prior to the researcher's first visit. All volunteers were to be accepted. Students were informed that they were expected to share their findings through an oral presentation to the class since the project work was to be in lieu of another assignment relating to advertising and marketing. Students were made aware that grading would be based upon self-evaluation and effort. It was emphasized that participation was to be voluntary and participants could elect to join another project if they desired. Students were encouraged to discuss the information given, and their possible participation in the project,

with their parents before consent forms were to be signed. Seven students, four male and three female volunteers, initially indicated interest and four had returned the forms prior to the researcher's first visit to the class.

The classroom teacher requested that the researcher begin the first of her visits to the school with a whole class introduction to the project and the game. Once again, the purpose of the study was explained and students were told that they would be given the opportunity to structure their own research.

The students were presented with information on both levels of the research design. They were apprised of the researcher's study and then were introduced to the student task visually through a written description, accompanied by an oral presentation, and diagrams on the chalkboard. They were given the option of taking the role of a spectator, a subject or a researcher. An open discussion ensued covering most aspects of the project. It was clear that some students expected the research "answers" to be predetermined and were consistently reminded that the answers were for them to discover. There were many questions of the "Can we. . .?" variety as students began to think about possible alternative project designs.

Since the students had just completed an introductory unit on advertising, the researcher used the analogy of a commercial for a cavity-fighting toothpaste to help describe the purpose of the students' task. The familiar reference to independent research supporting the claims made by manufacturers, so commonly used in television advertising, was used to introduce the project. It was explained that the students were expected to develop their research to prove or disprove the claim made by the game's architect that his product contributed to the development of creativity. They were given sanction to affirm or contradict the claim as long as they backed up their statements through their research.

After this discussion, seven additional volunteers signed up, giving a total of fourteen student researchers. The teacher and the researcher discussed whether or not to allow more

than the original anticipated number of seven participants. It meant some modifications would need to be made to accommodate the structure of the pupil-teacher interaction and data collection. The decision was made to accept the additional registrants because the greater number of students would more closely emulate a realistic classroom situation, and would provide extra data in the event some students chose to drop out of the project. As the researcher was interested in how classes of students might work with real world problem solving, it seemed appropriate to observe the larger group.

It was recognized that there would be more perspectives from which to view and triangulate the findings and it would let those who wished to give it a try, the chance to take a risk. It also offered students more ideas and options when conducting their research, such as greater selection of partners, information to draw from and alternative methods for sharing. Appropriate arrangements, such as consent forms from parents, were finalized for all fourteen participants.

To commence their research project, the students were given the choice of working alone or in self-selected groups. The student researchers formed and dissolved groupings until there were eventually eight working units in all: four students working individually, two pairs of same-sex groups, and two triads. All fourteen students, whether divided into their working units or as individuals, received the attention and instruction offered to everyone. They all wrote logs, designed research questions and collected data. Everyone experienced difficulties and received help from their peers, the researcher, their teacher and in varying degrees from their parents or others.

After the students' project had been completed, the researcher examined the log, project design, data collection, presentation and product of every student. The data were analyzed in light of the researcher's field notes, questionnaire and teacher's observations in order to interpret how the personality, leadership qualities, attitude and motivation of each student determined the problem solving process that individual employed. From the analysis of this information the researcher selected five students for the interpretation and detailed

discussion. The limited number was due to the descriptive nature of the study as having more students would have caused the work to be too voluminous.

Of the eight working units, the five students selected for this discussion were felt by the researcher to be typical of, but not identical to, the others. They were chosen because of the variety of approaches to problem solving they displayed. They comprised three of the units and spanned the entire range of student researcher behaviors observed. Two individuals, who worked alone, and one team of three students, were considered a representative sample of the whole group because they involved themselves and encountered problems in a fashion corresponding to those of the other units. The five students described expressed similar emotional reactions to frustrations and triumphs, employed parallel research methodologies, and engaged themselves in varying degrees comparable to the other units.

Data Collection

Data for the descriptions were gathered in several ways. All students were requested to keep journals that would be given to the researcher. The journals were to have three sections. The first was to be a record of the research; the second, a description of the problems encountered along with reactions to the research process and the third section was for a description of their feelings about the experience in general. The researcher requested and collected journals daily. Those that were submitted had their comments responded to and were returned before the next class. The journals were analyzed on an ongoing basis as well as after they were all collected at the end of the project. The classroom teacher was included in both the ongoing and post-project analyses of the journals and other data.

The researcher believed it would be beneficial to gather as much information as possible. Audiotaped interviews were conducted with the students individually and in groups. There were also interviews with parents. Additional student work samples and short stories were examined. Oral presentations of the research were videotaped.

To supplement the journals, observations, discussions and interviews, informal survey questionnaires were distributed to explore the student reactions after their experience with the project. The questionnaires were intended to probe student perspectives relating to their perceptions of their problem solving process. Questions were designed to explore perceived frustrations and problems, the problem solving process they employed, the types and effectiveness of support, the timing and changes in their emotional reactions and the value students placed on these factors in problem solving itself and as part of school curriculum experiences. (See appendix one for examples.)

The descriptions of the students' problem solving processes were based on observations recorded through the students' and classroom teacher's journal entries, as well as from the researcher's written journal notes and cassette recordings of the presentations, interviews conducted and questionnaires received. Tapes and field notes were transcribed onto computer disks. The discussion of the findings in chapter five is derived from the range of perspectives of students, parents and staff members, but reflects the researcher's own analysis and wholistic interpretation of the data.

RESEARCHER INVOLVEMENT

The researcher acted as participant-observer. The study was designed to be descriptive of the problem solving process observed. It was not intended to experiment with the students' problem solving, even though the situation had been created by the market research task. Direct interactions with students permitted the researcher to make observations of the students' behaviors while exploring their reasoning through discussion. Decisions for lesson planning and suggestions were based upon student work and questions posed. Flexer (1987) cited Ginsburg, Kossan, Schwartz and Swanson (1983) when describing clinical interview as "a dialogue between interviewer and child in which each response of the child determines what the interviewer asks next" (p.120). Flexer's

process and methodology were similar to the procedure used for this study in that this researcher's responses were contingent upon the responses of the subjects.

The researcher visited the fifty-minute Language Arts class daily, for approximately six weeks. During these visits she facilitated the students' market research and sometimes instructed them in research methodology and vocabulary. She offered suggestions on specific challenges and generally provided support for their research endeavours. While working with these students, the researcher also made observations of the units' problem solving process as they worked on their projects. She recorded these in a journal and on audio-cassette. Meanwhile the classroom teacher accompanied the remaining students to the library where they frequently worked independently, allowing the teacher to return to the classroom to observe the student researchers.

The time of involvement was extended from the proposed two weeks to six, because of the complexity of the task, and also because classes were often interrupted. Changes to the schedule were due to other commitments such as band camp, spring break, a peer support presentation, a field trip, band and literature presentations. During these times attendance varied and classes were even cancelled. Students usually worked in the classroom, but when necessary, were allowed to work with groups of subjects elsewhere in the building and at a neighboring elementary school. Some tested subjects at home and chose to work on their projects as homework.

The first session was used to introduce the project, familiarize students with the game by allowing them to play it briefly, and to provide opportunity for the researcher to begin to get to know the students. On this day the students actually saw the game, ascertained their responsibilities, began thinking about creativity, met the researcher and discovered how the researcher was going to be involved. The students' main research question,"Does this game contribute to creativity?" was clarified and reiterated numerous times.

The second day was a deeper introduction to the game and the research possibilities. The game boxes and journals were distributed. Again, the students were given time to play the game to familiarize themselves with its format and procedures. The class discussion centered around definitions of creativity and research design.

By the third day, although the choice of methodology had been left to the students, most were expressing ideas about experiment designs before clarifying how their experiments were being designed to show whether or not the game developed creativity. It was an opportunity to discuss various types of research and clarify the terminology of qualitative and quantitative research. The students were encouraged to discuss questions, methods, designs, possible problems and concerns. The researcher's questions were aimed at helping students to focus; and included such points as, "What is creativity? How are you going to prove that this game stimulates creativity?". During this period the students were also made aware of some of the various resources at their disposal, including the opportunity to interview the game's architect, if they chose to do so.

Subsequent class sessions commenced with a brief meeting or a discussion, then work-time for individualizing assistance. As the project evolved, lessons were designed around student need or questions posed. Vocabulary and issues were often the focus of the discussions. Terms such as: creativity, hypothesis, conditions, observations, inference, analysis, bias, support, evidence, limitations, methodology, interpretation, validity, generalizability, rigor, power and problem solving were explored. Student participation in the lessons varied with their level of interest and perceived need.

Often through the experience of their research and metacognitive reflection, student questions about the process itself became more focussed. Students' questioning became clearer. They talked about what they wanted, and needed, to know as issues were dealt with in class. The meeting component of the class varied in length, depending upon the complexity of the questions or problems which were addressed. Some portions of the

sessions with the researcher were spent in the usual teacher-class interactions including review of behavioural expectations, discipline or materials exchange.

As students responded to the stimuli of the research project and the sub-problems encountered, the researcher discussed observations with the students, the classroom teacher, and at times, in conversations with the students and their parents. Log entries were read on an interactive journaling basis so questions could be explored through the written mode. Rather than merely reading and interpreting the students' comments, the researcher used the journal as a vehicle for questioning, clarifying or elaborating upon student responses. The students' comments also provided the basis for lesson planning.

Two of the later sessions were given over to peer sharing among the investigating units. The students were grouped by the researcher to stimulate discussion from a variety of perspectives and to provide experience with a range of research designs. The researcher provided an optional basic structure for students to chose from as they prepared to share their presentations. This outline included the definitions of creativity used by the unit groups, the questions they were investigating, their research designs, findings and conclusions, if any. The unit groups were split up and mixed with the other units. Students were assigned to these temporary new groups to stimulate conversation, provide modelling and positive interaction. This afforded the students an opportunity to describe and discuss their projects objectively with others, as well as the chance to ask and answer questions in preparation for sharing their findings with the remainder of the class.

The final two days were spent sharing projects with the whole class and answering questions from the audience which consisted of the teacher, principal, peers and the game's architect. In addition to his being interested in the results of their work, Haynes' presence contributed to what Renzulli (1977) described as the necessity of presenting projects to a "real audience". These presentations were videotaped for later analysis.

After the project was over, individual students were interviewed and asked to complete some questionnaires about their process and reactions. They were provided with a pizza lunch in lieu of the time spent answering the researcher's questions. Copies of the written documents produced were given to the researcher along with the journals submitted. Many of the students and parents agreed to be interviewed in more detail, so the researcher visited their homes after the project.

Although part of the audience for presentations, the researcher's role was only that of observer of the students' products, and did not include participation in their evaluation. The classroom teacher, not the researcher, imposed the criteria for evaluation. The teacher set conditions on the students' projects for the purposes of maintaining continuity with the workload of the rest of the class. Students were requested to submit a two-page self-evaluation to their classroom teacher to determine a grade for the assignment.

To assist the researcher with observation of the students' problem solving process, the teacher shared with the researcher a few of the self-evaluations from the participants as well as a sample of their other written assignments. A short story provided insight into the students' writing styles and interests.

As well as the material provided by the classroom teacher, the researcher used questionnaires, interviews and conferences to provide additional sources for triangulating data. The researcher employed questioning as the primary method for clarifying interpretation of data. Analysis included looking for whether or not the students presented similar responses in other situations. Time was spent checking interpretation of findings to determine if statements were consistent with the classroom teacher's observations of what behaviors occurred in other situations or on subsequent occasions. Discussions with the classroom teacher were used to search for alternative explanations or disconfirming examples of responses. As well, data were examined as a method for determining what influence the researcher might have had on behavior.

SUMMARY

This study focuses on describing wholistically the problem solving process employed by five subjects, all ninth-grade Academic Challenge students from a large, urban junior high school. The problems encountered stemmed from a market research project attempting to test whether or not the game, FFlow, did as the game's architect claimed, turn on creativity.

The researcher was a participant-observer who visited the class daily for six weeks while the students worked on their research projects. The wholistic approach for the study was intended to allow the researcher to describe the process through exploration of the data from a variety of perspectives. The events are described through the interpretation of the findings rather than a chronological account of the events.

The fourteen volunteers for the project formed eight working units, of which only three will be described in detail. The units selected for the description include two students who chose to work as individuals and three other students who worked together as a team of one unit group. The students described were considered to be representative of the range of behaviors and problem solving processes observed, although each of the fourteen retained his or her individuality as he or she approached the project.

Project sessions included lesson plans, developed by the researcher, based on the students' responses to problems with their research. The researcher's questions were contingent upon observations of behavior and the answers brought forward during dialogue with the students. Closure was effected through student presentations to their classmates describing their projects and findings.

Data were collected through observations, journals, questionnaires and interviews with the students and their parents. The classroom teacher served as an observer for clarification and triangulation of data. The discussion of the findings is an interpretation of the problem solving process observed.

CHAPTER FOUR
FINDINGS

Chapter overview

The results stated below track the problem solving process of five, ninth-grade, Academic Challenge students working on a market research project of their own design. Daily visits by the researcher, over a period of six weeks, are recorded and described through a chronological account of the market research being conducted. Although there were fourteen student volunteers for the project, the researcher chose to focus on the investigations of only three of the eight working units as they structured their research. The remaining units were not reported in detail since their processes were similar, although not identical, to those described.

The structure of the chapter includes a description of each unit, followed by an overview of the research project, its question, procedure, product and presentation of findings. The researcher then presents her observations and findings for each unit, followed by a comparison between the units according to the stages in the problem solving process and personal attributes of the student researchers.

Each of the students is briefly described to provide the reader with an understanding of the character of the student. This is intended to assist the reader in visualizing the process observed by the researcher, since the problems encountered by the students spilled over into other aspects of their lives.

Data Analysis

Flexer's (1987) work provided assistance in data analysis through the structure of her article. She discussed internal validity and cited Miles and Huberman's (1984, p. 122) list

of ways of confirming conclusions in qualitative research, some of which were adapted to fit this study. These include:

- checking for representativeness,
- checking for researcher effects,
- triangulating,
- making contrasts and comparisons,
- replicating a finding,
- examining alternative explanations, and
- looking for negative evidence.

Data were analyzed in three ways. (1) During each session the researcher questioned the students for reasons behind their responses and made decisions about the researcher's own actions contingent upon the behavior of the students. (2) After each session, through log entries, discussion with the teacher, or from audiotape transcripts of sessions and interviews, the researcher read over field notes, replayed tapes and examined transcripts. Through discussion of observations with the classroom teacher, the researcher recorded significant incidents in another section of her journal while preparing the next session around student questions. (3) At the end of the study the researcher surveyed the cumulative data for trends as well as inconsistencies, probed for relationships and sought additional information through parental interviews.

Student-Structured FFlow Research Project Designs

Students were to conduct research attempting to test the claim made by Michael Haynes, the architect of the game, "FFlow", that his product developed creativity. They were to structure their research by developing a method to determine whether or not the game did as Haynes suggested, promote creativity. Students chose the type of approach they wished to use, since both qualitative or quantitative research methods were discussed in the sessions. Each unit proceeded differently and worked at a different pace. None progressed in a smooth, linear path from question to answer. Similar problems surfaced

at different times for different units. Each sought or refused assistance of their own volition. All seemed to go through the phases of developing a question, designing a method to test the question, gathering data, and organizing and presenting their findings.

Students were given opportunities to structure their own research in consultation with the researcher. They all claimed to be familiar with the fundamentals of a research process structure, but their initial questions were mostly focused on establishing parameters regarding their particular ideas. There were many, "Can we . . ." questions, to which the answer was consistently, "It's your decision . . . ". The students were very careful about establishing early the rules by which their research was to be governed. They were excited to have the chance to *affirm* or *dispute* the claims as long as they verified their opinions. The adolescent researchers seemed to be drawn to the idea of not having to agree with the architect's claims if their research could prove their disagreement valid, or the defence of their arguments convincing.

They inquired as to whether or not they could take advantage of the opportunity to make decisions and choose to conduct their research outside of the school. The students were given the choice of age of subjects as well as location for their research. The samples included elementary students from a neighboring school, family members in their homes, and students of a mixture of grades as well as teachers from the same school.

The participants were asked to generate a list of possible questions to guide the research which were discussed in class and often referred to for the duration of the project. The content of class discussions emerged from, and was contingent upon, the students' questions and comments. For example, Anne posed the question, "How will you know if your answers are valid?". Using her question as a stimulus, the researcher responded with more probing questions for all the students to consider. The issue of defining creativity was discussed along with methods of determining what constitutes proof, plans for research designs and criteria for sample selection.

Relationships between the question being asked and establishment of an appropriate research vehicle with which to test hypotheses were frequently discussed as the project evolved. Many concepts and vocabulary terms relating to both qualitative and quantitative research needed to be revisited as the students' experiences uncovered new facets and issues. Metacognitive discussion frequently centered around questions. Topics such as controlling variables, using precision and accuracy in reporting observations, along with whether or not the design matched the research question were addressed individually and in groups.

The students' decisions, made during the project, reflected more facets of problem solving than just their knowledge of research skills. Some students used the discussion and independent work-time as an opportunity to get over a temporary snag, while others took advantage of the flexible structure for activities such as: talking with classmates, recopying notes or drawing. The students responded to problems in a variety of ways, each having a bearing upon the progress of their work. Attitudes and approaches to problems influenced the effectiveness of moving past one challenge to facing the next.

FINDINGS

Five students were selected for this discussion because of the differences in problem solving approaches they presented and because they provided a representative sample of the data collected from all fourteen volunteers. The remainder of the student researchers displayed characteristics similar to the designated five and presented experiences comparable to those described.

Even though the five students selected shared many characteristics with the remaining units, there were always differences in each individual's problem solving process. Each unit formulated a different set of questions to frame both their research and their emerging problems. Each student thought about and reacted to the project differently and responded

to the researcher in his or her own manner. Students chose to examine varying social-emotional aspects of the game, focused upon different experimental designs or valued the project to varying degrees.

For the detailed unit descriptions below the students have been given pseudonyms to protect their anonymity. Quotations from their journals, reports and questionnaires have been transcribed verbatim and have been checked for accuracy of transcription when using the student's original spelling and grammar. Additional student information was provided by the classroom teacher. This included a sample of their writing, a short story assignment, which reflected the students' voice and interests.

UNIT ONE- LISE, MARGARET AND WILMA (Team One)

Student Characteristics

Lise

Lise was an articulate, outgoing, girl about fourteen years of age. Her tone of voice and manner seemed to generate a dominant force in the class. She was an accomplished writer. She wrote a short story, about an assertive and determined young mother, which was the school's representative entry for a national competition. Lise worked very quickly and got on task immediately. She did not often suggest a range of perspectives until they had been clarified by others, yet worked at getting the group to function smoothly and effectively. She tried to state points objectively and suggested she understands people as she sees them. She described herself as a leader,

> I've always been a leader, Wilma's always been a follower. I lead- that's what I can do. I don't like it always, but that's the role people usually expect of me. I get tired of showing and telling and explaining and repeating.

She was concerned with results and sought a quick way to attain them. Lise was able to adopt a structure then modify it to make it her own. She displayed strong initiative and leadership potential, generated many questions from a variety of categories, thought

carefully about ideas and strove to put forth a high quality product. Lise requested more time before handing in her log so she could think about it longer and perhaps strengthen her analysis.

She immediately formed a group with Wilma and Margaret. All three are of Asian descent. Lise seemed to appoint herself as group leader.

Wilma

Wilma was fairly quiet in class, yet seemed unafraid to talk openly with the researcher whom she had not known before. She would discuss with the researcher questions she had about concepts and vocabulary. She had some difficulties arranging time outside of class to work with her group because, as Margaret explained,

> She got in big trouble for going to the library with us on Saturday already. Her father wouldn't believe that she was at the library and her father doesn't like it when she goes to other people's houses.

Wilma's short story was unavailable for the researcher to review. It was unclear whether or not she had handed it in.

Margaret

Margaret spoke in a low tone of voice when conversing with adults, but her words expressed a wide range of ideas and emotions. Her short story was a well-written piece about a snake whose potency was underestimated until it was too late. She was known to the researcher before and seemed comfortable when sharing her problems orally or through her log. Her father had a great deal of research experience and was very actively involved in support of her schooling when the researcher worked with her previously. Margaret's statements reflected strong opinions, for example annoyance about the short amount of time for the project, yet she would go along with the flow of the group. She described herself using moderate terms,

> Some people may enjoy the competitive edge, but I personally like it when things are more relaxed.

Research project description

After playing the game, FFlow, a couple of times this group set to work immediately. They modelled their design upon examples offered by the researcher. They utilized classroom examples, copied formats and adapted pre-existing structures to meet the needs of their project. An example of this adaptive behavior was observed when they wrote a permission slip for their own subjects based on the one they had signed to participate in this research.

Question

Students in this team brainstormed a list of preliminary questions about the game, which included predicting interactions among players and hypothesizing possible results. From this pool of questions, the research team selected the most interesting or appropriate ones upon which to base their study.

They discussed the questions among themselves. A sample of their initial questions, quoted in the original language from their journals, is included:

- Do you become more creative & start to open up too if your friends start to begin to say profound things?
- How do you judge your peer's creativity?
- What do people think of creativity? How do people define it?
- How does FFlow compare to other methods in promoting creativity?
- Do you overtry to be creative when you know the objective of the game?
- Does age affect creativity? because there's 2 sides.
- If it is M/F group, M group, F group does the level of creativity change?
- Do players have a different idea of creativity than Michael Haynes?
- Does the game work better when your with strangers of friends or mixed?

A direct quotation from their report is stated below. Although the grammar and spelling show some flaws, the level of their thinking is visible. The example shows the selection of their question, and how they arrived at this decision.

> How well does FFlow promote creativity in different age groups. This question evolved and other questioned developed.
>
> 1. How does age affect creativity?
> 2. What do different age groups think about FFlow differently?
> 3. How do different age groups react to FFlow?

Procedure

Their method included pre-test surveys and post-test surveys of all subjects. Subjects were surveyed prior to and after having experienced playing the game of FFlow. They collected data by directly observing subjects playing the game and through the two sets of survey results. The team selected subjects for their sample according to the following age groups: 8-9, 14-15 and 20-40 years. The youngest subjects were from the neighboring elementary school. The remainder of the subjects were peers and teachers from their school.

They contacted their subjects independently and were permitted to work off campus during classtime at the elementary school. Much of the initial assistance requested from the researcher was related to seeking ideas about contacting subjects and obtaining permission to work outside the classroom. They expressed mild surprise and excitement about being "allowed" to venture beyond classroom walls.

They developed tasks such as defining creativity, creating permission slips, pre-surveys and post-surveys. Lise directed much of the activity, and they divided the workload fairly evenly. These students worked independently, often after regular school hours, to bring products to share for the next class. Using different source books found in the library, they gathered information about professional researchers' opinions and theories of creativity. Their preliminary tasks were completed within the first week. They were demonstrating progress by the third day of the project.

This team based their survey on questions from an Omni magazine article on creativity studies. Subjects were surveyed to determine their ideas about creativity, their perceptions of themselves as creative individuals, questions to be answered creatively and their opinions about whether or not they felt the game contributed to the development of their

creativity. The following entry, from the team's written report of their findings presented to the class, summarizes both their surveys and the positive approach to problems exhibited by this group.

> They were intended to show us if any improvements in creative thinking had taken place after playing the game. Unfortunately the surveys did not show this as clearly as we had hoped. However, they did confirm other observations.

Product

This group went beyond the classroom teacher's requirement by submitting a fairly well-organized, thorough, 16-page written report to complement their oral presentation to the rest of the class. The contents included almost all of the topics discussed during the project sessions and contained submissions from all three members.

Group members formulated the following hypotheses based on their background reading and questions generated.

> We had thought that the younger age group would show more signs of what the game claims it does. We thought this because the younger groups has less factors that may be an obstacle for the older age groups to allowing them to experience the real sensation of Fflow. These factors may be closeminedeness, the desire to be cool, competing to be grossest, favortism, etc.

> We believe that the younger our subjects are, the more creative they will be. As our subjects progress in age, we predict that they will become less creative. The decline of creativity could be due to the increase of peer pressure in older groups. Or, perhaps because "logic" sets in as we become older, and steers us away from thinking creatively.

Included in the report was a page of synthesized background information followed by definitions of creativity. They cited five recognized sources, contrasted with nine quotes from subjects as well as their personal definition which was,

> Creating and generating ideas without any restrictions or limitations.

Descriptions of the research design incorporated materials and method as well as provided samples of each of their surveys.

Although portions of the class sessions dealt specifically with distinguishing between observation and inference, there was still some blending of the two in the students' work.

This team included a few inferences with the two pages of observations they submitted. A sample of their statements quoted verbatim below expresses the overlap:

> Group A. 8-9 year olds . . .
> However, one problem that was prominent through the whole game and which none of the players seemed to notice, was the fact that some subjects were giving a thumbs up to a good friend regardless of his/her answer. One of them said, "I'll give you one (thumbs up) because you gave me one."
>
> Overall, this group was very acceptant of each other's answers. They only sent one person to the Wastelands and that was because he failed to give any response to the question put to him. . . .
>
> Group B. 14-15 year olds
> In this group, the competitive nature was quite evident. They rated each other fairly hard and several of them ended up in the Wasteland.
>
> After about 30-40 minutes into the game, this group began to lose interest . . . . One player who constantly received a thumbs down decided that this game was not worth her effort. She said "Can't I skip all my turns since I won't be able to get out of Wastelands anyways?"
>
> Group C. 20-45 year olds
> They judged each other easily and therefore the atmosphere seemed more relaxed than the one in group B. . . . The judging by this group was pretty fair throughout the game although their were a few exceptions. A couple of times a person would change his vote when he saw how everyone else was voting.

Presentation of findings

Conclusions and inferences were based upon their findings, and attempted to answer their research questions. Although they did not state whether or not they felt FFlow contributed to the development of creativity, they seemed to imply the game had the potential for unusual answers. They contended that certain conditions needed to be present, and that there were other facets in need of further investigation.

> We believe that the reason why the 14-15 year olds did not enjoy the game was because of the poor mix of personalities. Several of them commented afterwards that the game would have been more enjoyable if they were with their close friends and if they had been more comfortable playing an oral game . . . .
> We feel that if the game had included more aspects of creativity, i.e. artistic and writin, the game would appeal to a wider variety of people. In this way, people would come to understand that there is more to creativity than just thinking fast. Although questions allow more way for unusual answers. Answers can still be answered commonly.

> Based on the information gathered from these three groups, we believe that age has no significant bearing to a persons level of creativity. We believe this is so because the individual and overall results on the surveys were similar for groups A, B, and C.

In spite of the grammatical and spelling errors, it was evident that this group had prepared extensively for their presentation. They included some suggestions for new research problems such as the effects of the time limit, number of times played and player's "embarrasment [sic]" about answers, as well as contrasting players' ideas of creativity with those of the game's architect. They also suggested the following:

> Through this research we have thought up many more questions we would like to look into. They are:
>
> Can you teach anyone to become more creative?
> How long will this new level of creativity last?

Their report included a full page analysis of method errors. They described the problems they had with the surveys. For example, while creating the surveys, the team lost sight of their research question. As well, the subjects did not complete the surveys as the student-researchers had requested. The team had difficulty determining whether or not they detected what they considered to be "improvements" in creativity through the data provided by the surveys. The team mentioned the mix of personalities for "Group B" and felt that they could have made a better selection of subjects. They also commented on the limitations of the time frame.

> Also we wished we had more time to carry on our studies to further our theory and obtain more solid evidence. We didn't have time to confirm our observations to be true.

The oral presentation, a requirement of the classroom teacher, included all three students. They took turns speaking and constructed a poster to highlight their subjects' definitions of creativity along with the theorists whose work provided background for their study.

Researcher's observations

Lise, Margaret and Wilma ran into many frustrations and problems. They found frustrations with research design, time-tabling, interpersonal dynamics, parental restrictions, subject cooperation, coordination of scheduling, inconclusive results, and decision making. The team solved the logistical problems smoothly with minor assistance from the researcher. They spent a great deal of time discussing, sometimes arguing, until reaching a decision. They approached the researcher for suggestions. Most of the researcher's comments were in response to questions of permission, group dynamics and reactions to ideas they had already generated.

They had some annoyance when testing subjects of their own age. They were disappointed with their peers' behavior and the perceived lack of commitment the grade-nine subjects felt towards this team's serious research. They also felt that some of their effort had been wasted in that not all of the data they collected had been as useful as they might have hoped. As they got farther into the research the complexity of their task became more clear and they experienced feeling pressed for time and irritation with obstacles. Although they all took ownership of the project they sometimes blamed each other for setbacks and as the deadline approached they grew increasingly tense.

Their greatest problems came from interpersonal relationships. The two other group members expressed frustration at Lise's somewhat authoritarian style of leadership. Strong personalities in their own right, Margaret and Wilma remarked that they appreciated Lise's organizational skills and work ethic, but sometimes resented her forthright manner.

Margaret seemed to be pulled into the conflict between the other two girls. Each claimed Margaret as an ally. Margaret shared sentiments with each of her partners and recognized each point of view. She expressed that, at times, Wilma did not always meet their expectations, and Lise was overbearing. Margaret's observations of Lise seem to suggest

that the group's problems surfaced early, when the group was familiarizing itself with the game before working with subjects.

> After playing the game at noon hour today with Lise, Cleo, Charlotte and Ed, I noticed that I was becoming very frustrated. Lise was very influential, how she decided to rate you, was how everyone else decided to rate. Also, she was very picky about things, so the game lost its "fun" aspect and became very competitive. I think that the game was spoiled by Lise's determination to win and her influence over others. I know she does not intend to influence others but she still does.

Another log entry of Margaret's observations summed up the group's triangle of power,

> Actually, I'm kind of upset because Lise made up the survey all by herself without Wilma + Me able to have any input. We were working on it together, but I had to go home, and Lise sort of changed some of it. However, I have to admit that it's pretty good, but I did have some suggestions.

They resolved their problems through metacognitive discussion, log entries, compromise and sharing. They identified and dealt with each set of problems in a similar fashion. They expressed and vented their frustrations, tried looking at the problem from a variety of perspectives, communicated with each other, listened to suggestions, kept trying, kept their cool under pressure, seemed to let go of the pain, and enjoyed the feeling of getting through to the end. They all experienced anger as a result of frustration, but were able to get past it.

One of their most significant strategies for overcoming problems was to look at them in perspective and communicate with the parties involved. Lise expressed her problems almost whimsically.

> With a lot of barriers we have finally found 5 out of 6 subjects....Ira went away and Donald took his place— problem solved... Tim spranged his ankle today— problem made! Kerry hasn't been at school today— meaning no consent sheet— another problem. ... Oh boy! No worries, we'll get over it.

Margaret vented through expressions such as,

> The more I think about it, the more frustrating the situation is. WHAT A FRUSTRATING WORLD!!! Today, I think I've gone insane! ... However there is <u>some</u> good news. ...

Margaret seemed to suggest solutions to her problems even as she was identifying them, and mostly requested the reassurance that she could try the suggestions she was already making to herself.

Wilma also used the log as a place to vent her frustrations with Lise.

> It is however difficult to work with Lise sometimes because she thinks I'm not doing enough in the group. Sometimes the things she doesn't like doing she pushes it all to me and expects me to do it. Margaret knows how I feel and agrees that Lise is sometimes controlling us.

Although sometimes annoyed at problems during the project, especially when she felt things were not going smoothly or that Lise had structured much of the process, Wilma chose to stay and work in the group. She seemed to be able to push the priority of her emotional reactions behind those of completing the task. It might be assumed that she entertained the notion that things might have gone more smoothly if she had played a more active organizing role, but she did not compete with Lise for a position of power. Instead, she seemed to find comfort and support through Margaret's more neutral position.

By the end of the second week their interpersonal communication had helped alleviate many of their difficulties. Lise wrote,

> Margaret and I decided this project is fun. Well, I found out I have been kind of uptight lately. The way Wilma is can't be changed easily. We've all known for a long time that Wilma is a little bit irresponsible and dependent when it comes to school studies. We've all been arguing a lot lately. There hasn't been any permanent damages because we all understand why we're angry. We fight and then it's over. I understand why Wilma gets angry at me.

The pattern of their interaction reflected a series of peaks and valleys: intensity, whether anger or excitement, followed by frustration or progress.

Researcher's Findings

Significant to the overall problem-solving process was this group's early and genuine development of a definition of creativity. They looked up the word in the dictionary then they went to the public library and selected journals and books on creativity. They were the

first, and one of the few groups, to search outside the school for additional information, thus they formed a definition quickly and built a foundation to use as a basis for the analysis of their findings. Other groups tended to rely on this group's initiative for information on, and a definition of, creativity.

This group worked exceptionally hard. Their product reflected many of the structures and elements of research discussed in class yet they modified them to suit the particular structure of their project. Although some of their questions were not as original or insightful as some of the other units, Team One worked consistently and followed their method well. They generated questions for further research and used their time efficiently. Their productivity was strong. The creativity of their research was average for the class.

UNIT TWO- JAMES

Student Characteristics

James

James came from a secure, loving home with expressed strong religious beliefs. His parents were very involved in his life and often helped him with his homework.

James was a very good sketch artist. He often created elaborate drawings on his books during class. His short story sample, provided by the teacher for additional data, read like a video game. He spoke quietly to adults and was seen by classmates to be like a "nice guy". In class, James pushed his joking behavior to the brink of unacceptable limits, then calmed down and complied with classroom rules. The teacher suggested he and Mick, another of the student researchers, would run out of time on an assignment no matter how long they were given. She had recognized a pattern of getting after James to complete assignments on time, while having had to place additional emphasis on expecting good effort. James chose to play the game of FFlow with a group of the other students in class

for several sessions, but finally ended up not affiliating with a team, and finished the research project by himself.

Research project description

Since this study took place in a junior high school setting, and under fairly informal conditions, the researcher was cautious about maintaining order in the classroom. She was prepared for a variety of student responses to the situation, and attempted to strike a balance between encouraging student freedom and keeping reasonable control. James, and some of the other students, were somewhat exuberant; but at no time were any of them openly defiant, or rude; nor did they present limit-testing behavior beyond the range of typical teenagers. The researcher elected to allow a few days for concept exploration and idea incubation time, before testing assumptions and verifying observations about learning styles, work habits and classroom discipline.

James handled the research, and the project experience, very differently from Team One. Because of the difference in his approach, the researcher varied her responses to him, in an attempt to match her teaching style with the behavior he presented.

The description will present an alternative style due to this change. In particular, the reader can expect a degree of fragmentation, since the interchanges between James and the researcher were held as the issues emerged, and as occasions arose, *not* through routinely scheduled appointments. Although the interactions are described in somewhat chronological order, events did not take place in a smooth, linear sequence. Instead, contact occurred, and is described, on an incidental basis.

James was drawn to the project by a description given by the classroom teacher. He said he thought it would be fun and signed up immediately. His permission slip was one of the first to come back signed. Both the project and the researcher were new to James, and a moderate degree of excitement was evident.

James approached the research project by playing the game numerous times. Along with a few of the other boys in the research group, he played the game for much of the early work sessions. James socialized during class time and did little background reading.

It was only after the third and fourth sessions, when it appeared James was making little progress, that the researcher confirmed with the classroom teacher that a firmer style of leadership would be appropriate.

James, and a few other students, were given until the first weekend to provide some evidence of preliminary knowledge about creativity, before expectations relating to productivity were to be reinforced. The classroom teacher supported the researcher's decision to employ "regular teacher discipline techniques" to reaffirm classroom rules. The teacher agreed that research is based upon knowledge and that these students needed to develop a knowledge base about creativity from which to test the game. The students were already familiar with research methods from other classes, and needed to employ self-discipline to use their skills to gain the knowledge necessary to complete the research task. If self-discipline was not being utilized, the classroom teacher agreed with imposing discipline from external sources, either through herself, the researcher, or appropriate alternatives.

When asked about the discipline techniques used, the classroom teacher explained that, particularly for James, she had gone through a series of levels. The sequence included: (1) waiting for him to settle, (2) use of contracts, and (3) phoning his parents before, as she described, "he buckled down". Suggestions were made to the researcher to "talk to him straight". At this point the researcher spoke to James, and a few of the other students, regarding the calibre of their work. James' reaction to the discussion was passive; he smiled when some of the others responded in a joking manner.

During the first week, the researcher approached James twice, to observe and respond to his progress. The researcher chose to work from a position of recognition of positive features in an attempt to build upon them.

James' initial log entries were erratic, cryptic and frequently not in complete sentences. The first entry was dated a week after the project began, crossed out and replaced with the project's starting date. Instead of utilizing the researcher-suggested strategy of brainstorming a list of questions, as many of the other groups had, his log entry shows tentativeness and a deferring of commitment to an approach.

> I'm thinking of doing research with Grade 9's and grade 4's.
> -have a grade 4 sister so could have access to some of them
> -would like to play with friends judge for ourselves what it does to help us be creative. Question: could what is taken to be creative [unfinished and crossed out]

During a session when he had spent much of his time talking with other boys he quipped, "Creativity doesn't exist!" To which the researcher responded, *"You're welcome to your opinion, but prove it."* At that time the researcher sat down with him to discuss his progress again.

Question

James changed his research question several times. Four days before the class presentations, he was reminded by the researcher and the classroom teacher of his responsibility to share his findings with the class. Then he finally selected the question used for his presentation.

Procedure

During the fourth, informal progress conference with James, the researcher asked about his research question and log entries. James responded, "I don't get lots on paper— more in my head". He expressed taking time for learning the game thoroughly, and playing with research possibilities, before starting formal data gathering. James, and five other boys, had spent most of the classtime during the first two weeks playing the game. They did not

provide evidence of researching the topic of creativity from a range of sources, such as the reference people, magazines and books available. James also said he played the game at home with his younger sister.

The researcher's contact with James emphasized getting him to focus himself on his work, and put forth effort to explore some of the ideas discussed together until the next opportunity for interaction. During this time the researcher was providing individualized assistance to the other students on a rotating basis and was forced to leave him to his own work for portions of each session. This seemed appropriate, given the context and ability level of the students in the class. Interactions with James took place through discussion of the entries in his journal and points arising from his comments. Early in the second week of the project, his log entry, which spanned two sessions, read as follows: [The researcher responses are in italics.]

> I have played this game and discovered that the basic idea (theory) behind the game is correct in its analogy of promoting creativity.
> ***Source, proof?***
> However when refering to my own experiences and with other researcher's experiences the game when played seems to counter many of its claims. (Will explain later.)
> ***What are the factors which inhibit/promote creativity?***
> Now that I know how to play the game and have made some observations about the game, I have decided to research if the age limit set on the game is pertanant and if grade 4's even understand the game, etc.
> ***Is your question whether or not an understanding of creativity is necessary to have it developed through the game?***

Much of James' work presented generalizations. He had been watching other players while playing the game, but had not yet communicated a research plan. The researcher invited him to defend his generalizations through structured evidence collection and support from the literature. For example, in his observations he cited "non-creative— normal answers to questions such as what really happens in these situation [sic] " and the researcher asked for the criteria he used for assigning such labels to the players' answers.

He had also added observations of the participants during games being played:

> -laugh alot
> -often short answer
> -free with thumbs up
> -some times laugh during answers— can't get it out
> -often interrupt each other, try to help each other

-often refer to things they know of such as commercial
-accuse each other of not judging fairly

In response to the above comments in his journal the researcher inquired, *"Which of these might be elements of creativity?-refer to definitions of Haynes, etc."* Through discussion, James and the researcher talked about how he was forming the basis for his own ideas, and what definition of creativity he had adopted. It was suggested that he try other sources, besides a single dictionary, to strengthen the reasoning behind his statements. The following is an example of the researcher's suggestions recorded in his journal.

> *Go back over your observations, and highlight the parts you consider significant to the development of creativity. Use these as a basis for your research design. (They can become variables you can manipulate to explore).*

The researcher held several conferences with James, ranging in length from three to twenty minutes. Most of the interaction was conducted verbally since his notes were very sparse, providing little recorded information to build upon. All contact was initiated by the researcher. What written information James did present, depicted a struggle with determining and structuring a research problem. One of his research questions was offered through this statement from his journal:

> I think through the research I have done, my own experiences, and discussions I have had with other people about their observations of the game I have found the dominent thoughts of the game are that of does the game live up to its claims? Therefore I'd like to use this as my question.

Subsequent to this entry, the teacher met with him again to attempt to help him focus and shape how he planned to answer the question through a research design. The researcher mind-mapped, or webbed, the discussion on his journal page, so the possibilities for his research design might be recorded. James was encouraged to focus on a topic and make selections from that branch of the web which he found to be the most intriguing. The webbing portrayed variables related to the facets gleaned from his observations and knowledge. During the interchange many possibilities were generated. At the close of the discussion, James was invited to build upon any one of the suggestions or to design another which more suited his research interests.

The researcher used prompting questions to offer him possibilities from which he could select the path of his investigation. James spoke little during these discussions, but nodded and responded to direct questions. This mediative strategy (Costa, 1986) of providing cues and scaffolding for helping James to help himself, was an attempt to provide him with additional structure without taking over his project. This procedure was repeated several times.

Although James had been provided with greater time in conference with the researcher relative to the other students, and was given more specificity in suggestions as to how he might proceed, there appeared to have been little evidence of change in his output from one session to another. Observations seemed to indicate that, other than the discussions held with the researcher, he was doing little additional work during, or after, the sessions. He claimed he was thinking about his observations, but did not articulate details of a plan or his progress. Little information was communicated orally, recorded in the log, or produced in the form of notes to demonstrate how he was proceeding with the independent component of the study. During the remainder of the sessions he spent most of his time talking with other boys and playing the game.

Although James was making observations of people playing the game of FFlow, he did so without having developed a structure against which he could interpret his findings objectively. The evidence leading him to the conclusions he offered continued to be oral expressions of his opinions, based upon incidental observations made in the absence of a previously articulated research design. The other student researchers, whose work he was citing as supporting his conclusions, comprised the group with whom he had been playing the game. They, too, presented equally unclear and unsubstantiated plans.

As the project proceeded many sessions dealt with aspects of the other units' findings and discussions of their frustrations. For many students, this was a time for collaborative sharing of ideas and working though problems relating to methodology. James appeared inattentive during these large group sessions and did not offer many suggestions.

During group discussions, James was often adding to an elaborate drawing on the back cover of his journal. The scene was of a factory resembling a nuclear reactor. The character in the foreground was wearing a radio-active protection suit and carrying a wrench. The artwork was very precise with crosshatching and shading to give the impression of texture. There was a series of intertwining pipes drawn behind railings leading to buildings. The meticulous nature of his sketch was in marked contrast with his approach to creating a research design.

The researcher made several attempts to invite James to transfer to his project the same degree of commitment he showed to his drawing. James was exposed to a variety of instructional methods aimed at meeting a range of learning styles. He was given opportunities to work independently or with others, to receive information aurally, visually, and through kinesthetic modes; as well as having a range of choices for presenting information. Although many research ideas and plans had been discussed, no further evidence of progress was forthcoming.

By the third week of the project, after the Spring Break, the researcher emphasized the classroom rules again. This time the researcher spoke more emphatically to the five boys who had continued to spend most of their time playing the game and socializing. The researcher stressed that the evidence of productivity was lacking. Two boys left the game; one went to work by himself and the other joined two girls who had been having difficulty getting satisfaction from their research design. James and two others remained together and voiced their displeasure; the focus of their complaints shifted from being tired of the research project, to annoyance with classmates, to the game itself. Ricky, one of the boys remaining with James, suggested that he found the gameboard offensive. He claimed he felt the spiritual qualities in the artwork went against his religious beliefs. After Ricky's comments, James also seemed to develop an aversion to the game.

It was during his period of vacillation in choosing between, and defining, research questions that James expressed reservations about some aspects of the game. In particular, he uttered concern over the symbolism illustrated through the board design. James said, since he was a Christian, he was concerned about a possible, "New Age" influence which he felt might lure people away from the principles he valued. He discussed the matter with his parents. His father, a church pastor, examined the material. The father sent photocopies to a friend who was conducting some research into the New Age movement. The father, although initially concerned, read carefully the materials James had provided, and decided it was not cultish and was not a serious threat to anyone. James' father did not pursue the matter further. Throughout this time however, James did not choose to stop playing the game, nor did he stop allowing his younger sister to play.

James' log entry addressed the issue through disjointed phrases. His spelling and syntax seemed to indicate he did not reread his work:

> Note: Game seems to have NEW AGE. type influence in it, prismatic playing peices, many jungle type religions expressed in game board, idols, out of body experiences. Book of wonder contains N.A. ideas such as 8th way to play FFlow Nippon— the game of predicting the future, Earth FFlow Society Quarterly at back of book.

The researcher responded to James' concerns by drawing attention to the careful research methodology his father had modelled through his own investigation into the New Age aspect of the game. This was offered as a concrete example of another alternative from which James might choose to build a project. James was invited to go back and explore the symbolism to see if it related to mind control and contrast it with the concept of creativity.

The class discussions at this time centered around validity and reliability of results. Most students were developing a plan for sharing background information, the research question and design, observations and findings. The boys who had been playing the game with James disbanded. One went to work by himself and the other joined a boy who had started out working individually. James chose to work alone.

As the project was nearing its completion date, the working units had a chance to peer-coach each other in preparation for whole class presentations. They shared ideas and definitions of creativity and discussed methodology, questions, concerns and issues. James seemed to withdraw from this opportunity. The researcher approached James more directly in an attempt to probe the matter. He responded that he had been having difficulty structuring a question.

Product

During the last few days before the presentations, James' behavior in class was more settled. He separated himself physically from the other students and appeared to work more quietly. His work seemed to improve slightly in that his log began to contain some paragraphs reflecting potential research ideas.

> I've been thinking about my question and it seems to be greatly effected by the judging system, so I would like to do a question that encompasses this variable more.
> Question: Is the Judgement System a good judgement of creativity? or a good way to judge creativity:

The next entry in James' journal reflected what appeared to be his decision about the answer to his question without setting up a research design that would enable him test his idea.

> I have found that the rating system is not a good way to judge creativity because creativity ends up being whatever the judge sees it as.

This entry caused the researcher to question if it demonstrated an attempt to, in effect, skip the research portion of the project.

Again, the researcher supported his attempt and redirected his approach to include some foundation for his assessment. The researcher suggested James isolate factors which might influence judgement, and consider comparing them with criteria for determining creativity. He could then base these comparisons upon a definition of creativity from additional sources other than his own experiences and opinions to date. It was also suggested he might be able to test subjects by controlling some of these variables to provide evidence to support his hypothesis. At this point James selected the definition provided by

the game's architect and described some of the factors briefly in his journal, but did not set up any experiments.

By the fourth week all students were beginning to demonstrate some degree of progress with their work. The researcher continued to meet with James to check on his research questions.

Presentation of findings

James was first to present his project on the day scheduled for sharing. When his name was called by the classroom teacher, he shrugged and said, "I knew it, I'm always first.", and carried his log book up to the front. During his presentation the problem he stated was, "Is the peer rating system a good way to judge creativity?"

His presentation consisted of informal statements made to the group. He read from his log book and did not use cue cards or audio-visual materials. Although he incorporated many quotes from the discussions with the researcher, his method reflected loose observations, backtracking and a lot of reliance on his own perceptions, without providing much supporting evidence.

James' findings were stated as, "the rating system does not effectively judge creativity". His oral presentation was a reiteration of a page from his journal. The following, which he proceeded to read and speak from, is taken from the log. He had pressed so firmly when writing, that the impressions were felt four pages past the entry.

He stated that there were

> many factors that manipulate the effectiveness of this rating system. . . Some of these factors are:
> 1. A funny answer
> eg. If the answer was quoted from a funny comedian , from anywhere, and the judges did not know it but it was funny, this would not constitute creativity but they could get a thumbs up anyway.
> 2. If the judges like the answer.
> eg. The answer might have contain a put down of a person commonly unliked, and they could get a thumbs up although the answer was uncreative.
> 3. If the answer was perverse, disgusting or gory.
> Dependent upon the type of people you are with a perverse answer would

influence the judges to either give you a thumbs up, or down no matter whether the answer were creative or non-creative.
4. If the person answering is liked or disliked.
No matter whether an answer is creative or not, if the person is liked it will be much easier for them to get a thumbs up than normal and for a person who is disliked it is often very hard for them to get a thumbs up.

He met the classroom teacher's requirement of filling out his self-evaluation. He was not required to submit a written report with his oral presentation, and he did not.

Researcher's Observations

Through the peer sharing, James was made aware of how his findings seemed to support the findings of Team One's middle group, yet James did not draw attention to this aspect, nor did he identify the characteristics of the subjects upon whom he based these observations. The statements James made were true of the group of students with whom he had played so many games. This was observed, and verified by, the classroom teacher, but James did not refer to her observations and comments. His work did not reflect the classroom discussions about validity, reliability, research design, background reading or tentativeness of knowledge. He used his own opinions as the support for his generalizations about the game's development of creativity.

When he ran into difficulties with the research, James complained to his parents that he did not know how to get out of the project. He was defining his real problem as one of wanting to be finished with the research project and fearing he would be receiving a poor grade. Although he talked with his parents about his frustration after it had snowballed, he did not bring the matter to the attention of the teacher. His exchanges with the researcher did not address this issue and instead were spent suggesting additional research ideas.

His mother discussed James' frustration and fear of the grading with the researcher after his presentation. She was reassured it was through the self-evaluation that his grade would be determined. Another point of note was that his parents claimed they felt partially

responsible for not helping James out of his dilemma when they refused to allow him to quit. His mother also commented that James would work long and hard when interested in something, but could not get going when uninterested. He seemed no longer interested in the project.

The questionnaire all the students filled out after the project included direct questions about the problems they identified, and what they did to solve them. James' response indicated his problem was to avoid getting a poor grade and his solution strategy was to search for the easiest route out of the problem.

> I looked for an easy way out of this problem and did a reletively simple question.

After his mother's talk with the researcher, James expressed his other attempt to remedy the situation was to fill out his self-evaluation quite thoroughly.

Researcher's Findings

For most of his project, James relied heavily on his own perceptions and opinions. His comments indicated that he did not appear to benefit much from other than his own concrete experiences. His questionnaire rated the assistance provided, and peer researchers' experiences, as being of little use to him. His presentation reflected many of the discussions he had held with the researcher, yet his survey responses indicated he felt he had received little help. It would seem that the decisions James made during the project went against his preferred learning style. Although he might have needed to experience research for himself, he chose most of his research to be conducted through passive discussion of possibilities.

Points of significance seemed to be James' definitions of help, expectations for the project and willingness to commit to the rigours of research. Costa (1986) cited persistence, striving for accuracy and metacognition as some of the behaviors of intelligent behavior. Although James' intelligence was not in question, these behaviors were in contrast to, and

lacking in, his approach to the problems with his project. Persistence and accuracy did, however, seem to be present while James was drawing on his journal cover.

The most striking observation was James' apparent difficulty with taking ownership of problems. From the evidence presented through his comments, self-evaluation and questionnaire, he routinely assigned fault to external sources. Blame lay consistently with distractions from peers, the game, the researcher, the project design and his observations. These were all cited as causes which prevented everything falling into place for him.

UNIT THREE- ANNE

Student Characteristics

Anne

Anne was a confident, strong-minded fourteen-year-old. She described herself as someone who liked to be noticed, not caring if her teachers liked or disliked her, as long as they had some strong feeling about her. She preferred to make her own decisions and was drawn to the project only after she heard she could structure it herself. Her mother claimed Anne had always been that way. Even some of her first words were, "I can do it myself". Her mother explained that Anne's individuality stemmed from her left-handedness, since she had often found it necessary to devise ways of modifying the right-handed modelling of her parents. Her mother felt it had been best to encourage Anne's independence through a pattern of rehearsal, safety-backup and letting her try. Her short story was one whose main character was literally dying of boredom in science class and sinking away into oblivion.

Anne was involved in extra-curricular activities which exposed her to a broad range of experiences with young people ranging in age from 13-19. Her parents suggested she had

more freedoms than many of her friends, but that she had earned them because she accepted responsibility.

Anne seemed interested in the psychological facets of her findings. She was involved with "Peer Support", where teams of students were taught skills of peer-counselling. The teams were then made available to students who wanted to talk over minor problems with others of their own age. Anne seemed comfortable with people, but chose to work alone. She freely and frequently sought help from the classroom teacher, the counsellor, the researcher and others.

Research project description

As with James, the manner in which Anne approached her project differed from the others and called for another leadership style, as the change in the process description will demonstrate.

Anne had no intention of participating in the project until she heard from the researcher that she would be able to structure the investigation herself. Her classroom teacher expressed surprise at Anne's having volunteered.

Anne wanted to know exactly what was to be in the journal, she wanted to label the sections for her log book. After clarifying the rules of the project, Anne proceeded to establish her own parameters. She attempted to create her own definition for creativity and designed her own research method. She familiarized herself with the procedures and rigours of research and expressed many concerns about how to ensure the design she selected would demonstrate validity.

Question

Anne dived into activity and experiment design before she could explain where she thought her data might take her. She wrestled with controlling the many variables she had selected

for inclusion in her investigation. Consequently, she restructured her research questions to reflect what seemed to her to be significant from observations she was making.

Procedure

She finally settled upon comparing survey results with observations of subjects playing the game. She discussed her ideas orally and wrote extensively in her journal. She made a noticeable effort to act upon suggestions and comments from the researcher. Anne used her log to vent her frustrations but her entries also included questions, reflections, opinions and drafts of her survey instruments. She struggled under the mound of data she collected.

Anne chose to administer two surveys. Her original intent for the first survey was to sample sixty subjects, but she soon decided that task would be beyond her capabilities, energy and time constraints. She elected to scale down her sample to a more moderate twenty-six slightly younger peers from her school. She considered cost and distribution factors when preparing to conduct her survey. With some assistance from her father, who had previous experience with data analysis, Anne attempted to make statistical comparisons. Grouping the results by age, grade and gender, she claimed there did not seem to be much of a correlation between them and creativity. Some questions from her first survey for peers included,

> What does creativity <u>mean</u> to you?
> Do you think you are a creative person?. . . Why?
> Could you be more creative than you already are?
> How would/could being more creative change your life?

Anne had several of those surveyed play the game and made observations during play. She interviewed the players afterwards to determine if they liked the game and if they felt it increased their creativity.

Struck by the data from her surveys, and wanting to pursue it more deeply, she gathered new information and rethought her findings once again. Although she frequently re-read her findings, she did not edit the spelling in her log.

> I was very shocked by several of the results of my surveys. Some of the answeres suggested people with very low self-esteems and low self-concept. Results like those would suggest a deep rooted personal problem which may tint the results. . . . Unfortunately, because I don't know if those people played or not I have to make some assumptions . . . I'll talk to the school counsellor, and get his opinions so I won't be so much in the dark.
>
> "How someone feels about themselves determines the amount & level of creativity" ***source?***
>
> If creativity creates success- self concept follows.

Anne's second survey requested data from two adults and one fourteen-year-old from outside the school environment. This survey varied slightly from the first by asking for the subjects' definition of creativity and included a post-game written questionnaire which included Anne's operating definition of creativity.

1. Are you satisfied with the level of creativity you reached?

   "The state of FFlow is the experience of sinking into an effortless mental activity in which your skills are perfectly matched to the challenge."-Definition of FFlow according to Michael Haynes, inventor of the FFlow game.

2. While playing the game did you experience FFlow as defined above? (Explain).

Anne worked many hours examining the background information gleaned from the game's documentation. She re-read several times the definition of creativity employed by the game's architect, and studied the description of the FFlow experience as the "drugless high" of runners and other performers at their peak. She said she found the disclaimer particularly interesting, since the authors of the game insisted the creative benefits and results would have to be assessed by the player. Although she relied on many of the sources provided, she did not go as far afield as Team One for written material. She did, however, conduct more personal interviews of reference sources.

Anne tended to go deeper, past information to synthesis; she was reconceptualizing and probing, looking for trends and significant incidents. She sought to advance her existing knowledge and attempted to construct meaning from her findings.

Anne decided upon and stated her final problem and questions as:

> Does the boardgame FFlow increase creativity?
> Do players find the game satisfying?
> Do they reach the state of FFlow?

She asked for help when she chose and voiced much enthusiasm about the project. She frequently expressed her emotions when she was excited about her ideas or when she was frustrated over a snag.

She was the most self-initiated of all the students observed. Anne did not wait for assistance or results to come back, she set her own tasks and found ways to fill her time. She claimed she felt frustrated sometimes at not getting the help she wanted, but it seemed more an observation of the phenomenon that the information she desired was yet to be constructed, a consequence of original research. She soon recognized that it was she who shaped her progress. Anne spent many extra hours on the project, reading, writing, and discussing it with the counsellor, researcher and others. Her self-evaluation presented her appreciation for the interactive nature of her analysis,

> I found a lot of snags & it was good that someone was there to help.

It seemed obvious through her extensive comments and cumulative questions she thought deeply about what she was observing and what it might mean. She openly discussed possibilities and would go back over and reread her data and background information often to check for supporting evidence. She found the awe with which her peers regarded her work insufficient for assisting her with problem formulation.

> My question kept changing. When I asked people to tell me what was wrong they just told me it was good, but I needed "constructive criticism".

Although Anne worked mostly independently, the researcher, classroom teacher, school counsellor, and her parents all had a definite facilitative role. Anne ran into problems headlong, and desired someone with whom she might discuss her ideas, questions and concerns. Anne suggested and considered alternatives, discussed possibilities, listened

intently, made her own decisions and continued on. She had numerous questions, usually about rigour, rules and structure of research,

> Would my research be complete if I leave that out? I don't know if I'm allowed. . .

Anne also found peer conferencing helpful. During the sessions when students were in groups to share their work and prepare for the presentations, Anne worked with Hugh, from one of the other units not described in this study. Hugh and Anne interviewed each other to clarify the direction of their projects. One of Hugh's talents was asking very astute questions. His focus and genuine concern about Anne's work helped her make decisions about what she wanted to say and how she was going to say it.

Product

Anne submitted a twelve-page, thorough, type-written report along with her presentation. Her report included many graphs comparing subjects which seemed to reflect her father's assistance in their construction.

Presentation of Findings

Like Team One's report, Anne's pages of observations included some inferences as well.

> Subjects are finding it hard to "be" creative.
> One subject is becoming extremely frustrated because he's unsuccessful.
> One player tends to dominate the game.
> People get very frustrated when they don't get a good rating. This group has everyone in Wasteland and they're having a hard time getting out. They have the attitude, "If I can't be creative than he can't either."
> People continue to discuss questions after they've been answered, laughing and sharing how others might answer, or praising the one who did answer, often sparking more creativity

Anne voiced some of her own reactions to the game.

> I really do not understand the correlation between FFlow and Hawaii. I've experienced FFlow lots of times and I've never been to Hawaii. I think there is too much paralleling between the game and Hawaii. A far away island is good, but it almost seems as though the game is based on Hawaiian folklore.
>
> In my opinion, competition plays a key role in determining whether or not one reaches the state of FFlow. Part of this is due to the need for competition in all of us, whether, unfortunately, it is positive or negative. Assuming that

> during the state of FFlow such a need must be met. I think, when playing the game people must realize the challenge is against themselves, the others are facing their own challenge.

Her findings reflected her additional research into the social-emotional aspects of creativity and answered the questions she posed.

> One group I observed were timing to the second, 30 seconds, even if you were in mid-phrase, or didn't hear the question . . . . The ratings weren't strongly measured on creativity, but on believability. . . . This competition, in my opinion, was negative. Even though they had fun I don't think they were being fulfilled by the game.
>
> I was somewhat shocked by some of the results on my questionnaires. . . . Some of these answers may suggest people with low self-esteem and low self-concept. In my efforts to keep my subjects anonymous I am unable to track down these people to see if the game helped them so I've chosen to speak to an expert in the field. . . .
>
> Based on my findings, I believe that the game of FFlow does increase creativity. Levels of creativity were raised in different ways for different people, but was successful in each.
>
> Through my research into the game of FFlow, I have found that although not all the subjects said they reached the state of FFlow, it is possible, and if the game is played properly, it is probable that this state will be reached.
>
> All of the subjects found the game fun and relaxing, if this proves satisfaction, then the game is once again successful in its claims. However, I do think it is wise of Mr. Haynes to include the disclaimer in the game.

Anne provided "Further Recommended Research", which she explained was, "Due to time and other constraints I was unable to pursue all possible leads.". She wondered about several additional questions such as, "Can FFlow really help those with very low self-esteem? Does age affect levels of creativity?". Her report was clearly related to her research design and she submitted it along with her questionnaire and self-evaluation. She made an effort to support her generalizations through her observations and by quoting her counsellor's comments as well as adhering to the written claims made by the game's architect.

Researcher's Observations

Anne made definite decisions and accepted the parameters she set for herself. She faced the problem of having too much to hand in and discussed sequencing and organizing with

the researcher. Another discussion generated ideas about how to share information visually. She elected to leave visual aids out of her presentation because of the time she spent on creating her report. Anne did a lot of work and thinking in the process of completing her research.

Researcher's Findings

Anne's approach to the problem solving reflected many of the behaviors on Costa's (1986) list of indicators of intelligent behavior. She intuitively seemed to know what to do when she did not know what to do. She displayed confidence in her ability to arrive at solutions. She metacognitively analyzed her decisions by making predictions about consequences of alternatives prior to choosing from them. She listened very carefully and strove for accuracy, yet possessed a tolerance for ambiguity. Her log comments were usually speculative,

> I think my background information is complete.
> I might. . .
> There doesn't seem to be much of a correlation between them. I'm really not sure. . . I was shocked by. . . Results like those would suggest. . . which may tint the results.

When she encountered difficulty, such as not being sure about how to send out her surveys, or how best to condense and present her findings, she would approach it with a positive, yet balanced, outlook, offering suggestions to herself.

> Maybe there is another way to do the survay, without using so much paper. Maybe a phone survay? But I don't know if I'm allowed to do that.

> I'm also not sure how much I should present. I don't want to just rattle on, but I want to look like I worked. I don't know- I'll figure something out!

She looked for connections between what she was finding out and what she already knew by talking around and about her topic. She looked farther than the words on the pages of data she was collecting. She appeared to take the project very seriously and put much of herself into her work.

Summary

The research project was classified by its design, question, procedure, product and presentation. Although the same categories were used to describe all of the students' projects, the variety of approaches used by the student-researchers accounted for differences in the style of the descriptions. Student characteristics were included to assist the reader in visualizing the process observed by the researcher. Anne and James worked independently while Team One, consisting of Lise, Margaret and Wilma, worked together. The descriptions of the units varied with the manner in which they approached their research task, and by the researcher's attempts to match the students' stages of self-directedness with her teaching style.

COMPARISONS BETWEEN UNITS

The units will be briefly compared below to summarize the findings relative to the stages of creative problem solving and attitudinal factors. Discussion in chapter five will center around comparison relative to a model of the problem solving process synthesized from themes emerging from the data.

The classroom teacher summarized her observations of the process by drawing attention to the distinctions between the members of a group of students all identified as being of high ability. The differences she mentioned suggest additional dimensions to the problem solving process than simply defining and solving problems. She commented:

> In dealing with the task they are revealing a lot about themselves as learners:
>
> risk taking vs. insecurity
>
> group learners vs. individuals
>
> leaders vs. those who procrastinate

The classroom teacher's observations seemed to intuitively reflect several of the constructs of problem solving and creativity. For example, Kirton's (1976) adaptors and innovators seemed to match how the students designed their projects. Flexer's (1987) extrinsic and

intrinsic problem solving styles and Seeley's (1985) fluid and crystallized intelligences seemed to support the way individuals approached problems and sought assistance. Myers, Slavin and Southern's (1990) leadership styles seemed to support the manner in which interpersonal relationships were handled, and the way units responded to assistance.

All students found times when their work stalled, but perhaps the feature which most distinguished one from another, was what happened when the frustrations occurred. These incidents have been summarized and compared below.

Identifying, defining and owning the problem

Team One and Anne seemed able to articulate what was causing their frustration. They were able to find and define their problems readily. They entered into metacognitive discussions to state the problems in terms of being within their power to control, even when some aspects of the problems were not. James tended to experience difficulty formulating the problem statements as well as the cause and structure of the problem, and was reticent about discussing difficulties metacognitively. Anne had difficulty initially formulating her research question, yet was able to define her logistical problems quickly.

Frustrations and problems stated in their questionnaires included:

Team One: I was frustrated by the gr. 9 immaturity. I was frustrated with partners lack of responsibility and also with subjects. . .

- lack of information (surveys incorrect)
- unreliable observations (gr.9's)
- lack of faith in partners

James: I found I got frustrated because I did not know what was expected of me. I also had difficulty understanding what you were saying sometimes

I identified getting a poor mark as a problem.

Anne: My question kept changing. . . .

-that my answers weren't solving the questions I was asking.
- I knew my work wasn't perfect and I wanted to find the mistakes and fix them.

Developing and carrying out a plan

James seemed to have difficulty creating ways out of his problems by himself. He would nod when the researcher assisted with generating alternatives. He did not provide evidence of having predicted their consequences, nor did he appear to carry them into action. James dealt with consequences as they arose. He discussed his difficulties with his friends and his parents, but on his questionnaire he commented, "I don't recall receiving any help really".

The other two units generated many alternatives, predicted consequences for each of these choices and selected courses of action. They sought assistance from each other, peers, the researcher and other adults. Comments made indicated that they found they had received help when needed. They made specific, sequenced plans to accomplish their set objectives. Both Team One and Anne sometimes had to go back and reclarify their objectives and plans, but they carried through with revised plans.

Monitoring and evaluating the plan

Anne and Team One quickly recognized when the strategy they were employing did not seem to be working. They rapidly sensed if things were not going right. They suggested possible causes and routes, but moved from the stalled position promptly. Solution routes Team One cited included:

> We received help from you and peers. Also, we looked up inforfamtion from acknowledged sources. We discussed problems with peers and asked how they managed to overcome their own problems.

James' behavior during this stage differed from that of the other units. He seemed not to recognize his control over the creation of a plan, so monitoring a plan seemed pre-empted. Since he did experience frustration with the lack of resolution to the problem, he was able to evaluate his reaction, but did not seem to be consciously evaluating the effectiveness of a plan to deal with it.

Attitude, persistence and action

One of the self-evaluation questions was to describe the student's commitment to this task.

> Team One: I was very enthusiastic about the project at first, however the interest soon died out, but I kept with it. . . . I thought I put a lot of work into this research.
>
> James: My commitment to this task is never what it should have been, because my perceptions of what this was was not clear.
>
> Anne: I feel that I was very committed to this project. I used a lot of my free time to work on it . . . I'm proud of what I accomplished, and I believe in my results.

Team One and Anne spent time thinking about solutions rather than dwelling on the frustration of being stuck. They were frustrated, but got on with the task. They were in almost constant forward motion, even during setbacks. The time spent thinking about the problem seemed to enable them to come up with possible solutions.

Team One suggested,

> We talked them out until we had listed several alternatives and we picked the best one. Problems we could not do anything about we specified as method errors.

James, on the other hand, seemed to languish in the stall. His paralysis seemed to shut down his generation of problem statements either about the research or the difficulty he was having with it. It also held up generation of possible alternatives and his willingness to attempt solutions. Rather than employing a "trial and learn" (Phillips Petroleum Company, 1977b) strategy like the other units, he seemed to stop and wait. Attempts to jump-start his process were only moderately successful. He did not seem to invest in the solution. He admitted,

> I looked for an easy way out of this problem . . . .

Project Products

There was a dramatic contrast between the products of the other units and that of James. Team One and Anne created thorough and complete reports, which went beyond the requirements of the project. James' few pages of journal entries were the only artifacts representing his work. The students all seemed relieved when the project was over. Lise, Margaret, Wilma and Anne consistently expressed pride in their accomplishment and fatigue for having put forth so much effort, but James did not express any pride in his product.

SUMMARY

While working on the research project, each student encountered a variety of problems, many of which were superficial and related to the logistics of getting the research started. Other problems evolved as a result of the study itself and some were of a more personal origin and linked to the individual's personality and past history. All students encountered problems at different times. What seemed momentous for one may not even have occurred for others, or it was considered to be ordinary. This finding supports the work of Coleman and Shore, (1991); Frederiksen, (1984); Getzels, (1985); Sternberg, (1985b) and Zentall, (1990) when they suggested that problems are related to the problem solver and the context of their solution.

All students felt a sense of frustration and a feeling of being overwhelmed at times. All wrestled with the ambiguity and complexity of issues. Each had to make decisions about which alternative to take. Finally, they had to shape their own solution and deal with the consequences of their choices. Some were more able to predict consequences than others.

Team One approached their problems efficiently and worked together to solve them. They encountered a variety of problems with the most significant being those of an interpersonal origin. James had difficulty structuring a research question and felt frustrated with his perception of not being able to quit. Anne extended her research by generating additional questions evolving from her hypothesis about self-esteem affecting creativity.

These findings will be discussed in chapter five according to the constructs from the literature and the emerging themes from the data. An interactive model of problem solving will be introduced as a means of comparing the factors contributing to the problem solving process observed.

CHAPTER FIVE
DISCUSSION

Chapter overview

The literature relating to the field of problem solving presented several constructs which helped to explain the behaviors exhibited by the student-researchers. Analysis of the data revealed that there were many facets to the problem solving process observed through this study. These facets were open to a variety of classifications and have been grouped by a number of common themes. The students' problem solving process overlapped the themes and the constructs so a blended clustering was necessary to facilitate discussion of the data. Five composite structures formed a model interacting with problem solving which became the basis from which comparisons were made.

The constructs will be briefly reviewed and amalgamated with the themes to become the components of an interactive model of the problem solving process. This model will be explained and used as the foundation for discussion of the process observed as high ability students conducted a market research project.

Merging constructs-Emerging themes

Educators are attempting to help students learn to solve problems wisely, but the fields of learning and problem solving are very broad. There are several constructs which are discussed separately in the literature. This separation might be taken to imply that the constructs act independently, but this researcher has found them to be interrelated and interactive. It was not the purpose of this researcher to suggest that there are blind spots in the findings of other researchers, but it is hoped that her synthesis of the parts described in the literature, together with the themes emerging from the analysis of the data from this observation would produce a whole, working elephant. The model formed from the findings might help explain the process observed The facets of learning and problem

solving are interdependent and combine to become intellectual growth. Feldman (1988, p. 275) suggested,

> development is not solely the result of changes within an individual, catalyzed by transactions with the environment, but is instead the result of a coinciding of a number of forces— some internal and some external— that set the stage, stimulate, and catalyze change .

This view of change could also be applied to an individual's problem solving process because several factors work simultaneously to ignite problem solving. These too, may occur both internally or externally in the life of the problem solver. It is the unique combination of these forces that develops into the problem solving process.

Analysis of the data revealed several major themes which, operating during the problem solving process, intermingled with the constructs in continual interplay and had direct bearing upon the actual problem solving process exhibited by the subjects. The themes appeared to be a manifestation of style-individuality including elements of: persistence when facing a struggle, commitment, resource management, behavior pattern or habit, beliefs, ability, interests, interpersonal relationships, and metacognition.

These themes, together with the constructs from the literature, are parts of the individual's style of problem solving. They are considered to be discrete, yet interrelated entities as exemplified by Lewis M.Branscomb's (c1984) quote.

> People seldom distinguish among data, information, knowledge and wisdom.
> Yet they are as different from one another,
> and as interlocking
> as starch molecules, flour, bread
> and the flavorful memory of a superb morning croissant.

While the parts offer a variety of factors considered to affect an individual's problem solving process, it is the manner in which they interact that creates problem solving behavior. Whether these factors exist separately, but in balance, or are blended into a combination, they present themselves differently with different problems. Problem solving

behavior as a whole depends upon the way the individual problem solver perceives and interacts with the parts.

Some form of organization is needed to make the *dough* of the information manageable. Therefore, the themes and constructs are consolidated into a composite of five factors for this discussion. This aggregate will be described and used as a basis for comparison of the research groups, but first the constructs will be reviewed to highlight the interrelated facets.

Constructs

Several researchers have identified what they believed to be constructs that operate during the problem solving process. This accumulation of ideas is recapitulated below. The significant overlapping of ideas caused the researcher to combine related constructs for the purpose of summarizing.

- ***Definition of real problems.*** (Kanevsky, 1990; Renzulli, 1977; Sternberg, 1985b; Treffinger & Isaksen, 1992). Real problems happen in the life of the individual. They may be ill-structured and dependent upon their context; but because these problems matter to the problem solver, they drive the action.

- ***Problem finding, problem definition and formulation.*** (Bransford & Stein, 1984; Frederiksen, 1984; Getzels, 1985; Osborn, 1953; Parnes, 1981; Sternberg, 1985b; Treffinger & Isaksen, 1992). A problem must be recognized and defined before the process of solution is commenced. How a problem is formulated has a great impact upon its solution.

- ***Classification of problems by structure.*** (Greeno, 1973; Sternberg, 1985b). This includes well-structured problems, ill-structured problems and structured problems requiring productive thinking (Frederiksen, 1984).

- ***Problem solving skills, training and transfer.*** (Crammond et al. 1990; Osborn, 1953; Parnes, 1981; Perkins, 1986b; Skemp, 1990; Treffinger, 1992). This includes Creative Problem Solving and other process training. Sternberg and Davidson (1982) use the term, *executive processes,* to explain how skills such as meta-memory (Weed, Ryan & Day, 1990), automaticity (Zentall, 1990), and schema inducement (Phye, 1990) are aspects of an individual's functioning which are at least partially within his or her control and may be improved through training. These brain functions as well as proceduralization of problem structures are important facets of training for transfer (Perkins & Salomon, 1988). Phases of meaningful learning (Shuell, 1990) also relate in that they are not linear in nature, but rather interactive and cumulative.

- ***Problem solving styles.*** (Flexer, 1987). An *extrinsic* style focusses on external rules and correct answers. Using *intrinsic* style, the solver develops and evaluates solutions.

- ***Intelligences.*** (Seeley, 1985). Quick adaptation to unfamiliar stimuli, with little reliance on previously learned strategies are indicators of *fluid* intelligence. *Crystallized* intelligence requires previous training and logical inference. Multiple intelligences are recognized by several researchers (Gardner, 1985; Guilford, 1966; and Sternberg, 1984).

- ***Styles of creativity.*** (Kirton, 1976; adapted for use by Treffinger, Sortore & Cross, 1992). The *Adaptive* style of creativity is used when an individual is trying to do something better by existing rules. *Innovative* creativity is trying to do something differently by inventing, modifying or ignoring rules.

- ***Intelligent Behavior.*** (Costa, 1981; Renzulli, 1970; Sternberg, 1985b). Since there is no clear consensus of the traits of giftedness, the researcher found it more productive to focus on intelligent behaviors, including such skills as metacognition and persistence. The behaviors of good problem solvers, (Hoover, 1987) included similar and related characteristics, such as abstract reasoning, structuring ambiguous tasks, identification of problems, fluent strategy production, planning, selective encoding of relevant information and synthesis. Lester (1980), cited by Flexer, (1987), included interest, confidence, risk-taking, fluency, critical evaluation and creativity.

- ***Creative Productivity.*** (Treffinger, Sortore & Cross, 1992). Treffinger et al. suggested creative productivity is a function of COCO, the Characteristics of people, the Operations they perform in their Context leading to Outcomes, which comprise the climate for good problem solving. They based some of this on the work of Les Jones (1992), when they exposed blocks and barriers to creativity. *External* blocks are found in the thinking climate, and include trust, and support for ideas. *Internal* barriers consist of four main categories of influences upon creative productivity. Strategic barriers are the individual's preferred methods for solving problems, which may overshadow new methods. Values barriers come into the degree of flexibility in applying beliefs in order to use new perspectives when viewing ideas. Perceptual barriers may rely heavily upon the use of senses and awareness in habitual ways. Self-Image barriers

prevent the individual's assertiveness and confidence in his or her abilities from emerging. Treffinger et al. also based some ideas on the work of Ekvall, (1983) when they addressed the group climate for creativity, which includes challenge, risk taking and time to develop ideas.

- ***Leadership Style.*** (Myers, Slavin & Southern, 1990). Authoritarian leadership develops when an individual with a dominant personality attempts to control group productivity. Participative style invites group input. This type of leadership lets the group feel a sense of control, even if the leader has subtly influenced the direction. The leadership style may foster or discourage productivity. Other styles include process leadership which surfaces for particular purposes. As well, Grow's (1991) Stages of Self-Directed Learning include matching learner stages of dependent, interested, involved and self-directed learners to teaching styles of Authority/coach, Motivator/guide, Facilitator, and Consultant/delegator.

- ***Motivation for learning or performing a task.*** (Biggs & Telfer, 1987) There are four categories of motivation defined as: Instrumental, or because of the consequences; Social, to please people whose opinions are important; Achievement, competing to feel good or to enhance egos and; and Intrinsic, because of curiosity and because the learner wants to learn.

- ***Individual Learning Style differences.*** (Coleman & Shore, 1991; Dunn, Dunn & Treffinger, 1992; Gregoric, 1980; Kanevsky, 1990; Kitano, 1985; McCarthy, 1980; Montague, 1991). These researchers draw attention to the individual differences and preferences of learners. They also include

classifying people by psychological type based upon the Myers-Briggs type indicator (Meisgeier, Murphy, & Meisgeier, (1989). These categories are used to describe preferences displayed by learners in the manner in which they receive, organize and present information and how they orient themselves to the world.

A COMPOSITE OF INTERACTING CONSTRUCTS

There are many difficulties in dealing with concepts as nebulous as the preceding constructs, not the least of which, is paradox. By their very nature, these constructs are difficult to pin down, because they are still in the process of becoming understood. In an attempt to describe a phenomenon, researchers and theorists offer constructs as a kind of *intellectual zero*; holding a place until an explanation value is developed. Returning to Lipman's (1984) philosophical discussion, it remains unclear whether a construct is *discovered* or *invented*, but one thing is clear; comprehension of a construct evolves through study, evidence, idea-testing and reflection. Themes emerging from data seem to provide both the fodder for the discovery and development of constructs *and* the variables from which to invent and test them.

Another difficulty with constructs lies with arbitrarily imposed polarity. Roger von Oech (1983) cited Kenneth Boulding, who suggested, "there are two kinds of people in this world: those who divide everything into two groups and those who don't" (von Oech, 1983, p. 29). The imposition of dichotomies limits possibilities because they offer only two choices. When a construct is based upon two bipolar dimensions, the "either/or" labels give an impression of mutual exclusivity. What might be needed is exploration of the boundary layer between the poles of any continuum to discover combinations, giving way to new interpretations or flexibility.

Conversely, the value of a dichotomy rests in the clarity of vision made possible because of the distinction provided by clear contrast. The brain thrives upon contrast; it stimulates brain function (Sylwester, 1990). Contrast seems to provide balance in nature, the yin and yang of life itself. Maybe another way to view contrast is that, instead of two parts in opposition, consider it two complementary aspects which together form a symbiotic whole. Only in relation to each other do the facets meet their systemic potential. Still another way to view contrast, is that it is an attempt to structure a complex system. By analyzing and breaking up the process into its parts, the learner can synthesize new solutions to problems. By designing results of interaction the discretion of the parts remains intact.

However, the shades of grey perceived by gifted students and the fuzziness of the issues of modern society force consideration of additional possibilities and tolerance for the ambiguity necessary in a pluralist society. Issues such as pollution, prejudice, abortion and genetic engineering, made possible through man's ingenuity and technology, are posing complexities of problems beyond the simplistic scope of traditional problems. New advances create new problems, particularly in the ethical and moral domains. Students of today and tomorrow need skills in being able to cope responsibly with such demands on their problem solving abilities (Berman, 1990).

This concept is not restricted to social sciences. Physicists are becoming more willing to entertain notions of combinations of elements previously believed to be discreet. Multi-faceted phenomena such as light, which behaves as both particles and waves are now being considered in tandem, for example as "wavicles" (Sinclair, 1969). As technology enables researchers to bring atoms closer to the temperature of absolute zero, they are discovering how elements behave in similar ways. Part of the irony here is that each new step in the unfolding drama of particle study results in another dichotomy. Even with sub-atomic particles, it appears the difference between bosons and fermions lies with whether the particle has a whole or half-integer spin. The properties of groups of particles, like atoms, are dependent upon the "sum of the spins of the constituent particles" which also is

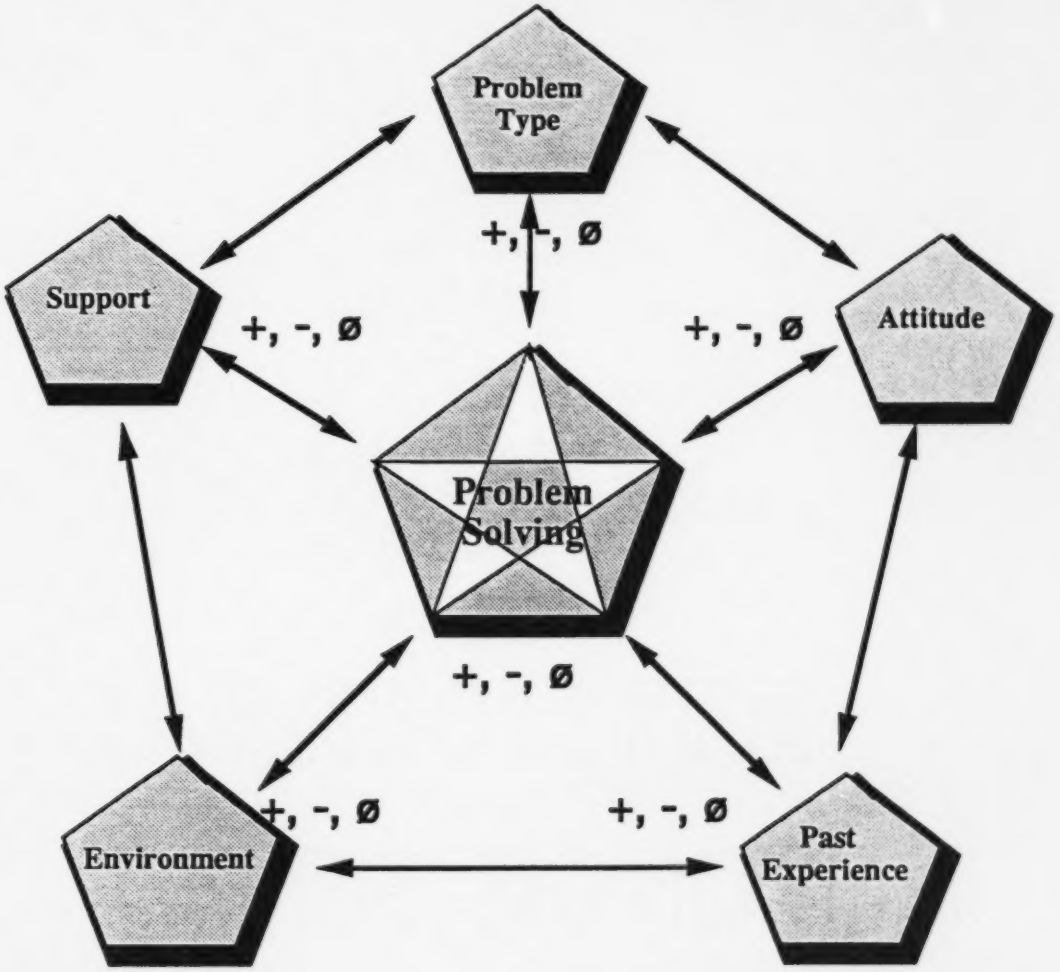
expressed as a whole or half-integer. (Freedman, 1993, p. 64). The properties of matter are described as simply the result of the cumulative spin of the combination of particles, like electrons and protons.

Similarly, the properties of problem solving result from the combined spin of the composites influencing the process. The differences in the process are a result of the way the problem solver behaves relative to the the sum of the composites. The constructs previously described, therefore, are merged with the themes because of the overlapping of their facets. Themes such as persistence when facing a struggle, commitment, resource management, behavior pattern or habit, beliefs, ability, interests, interpersonal relationships, and metacognition broach the constructs as evidence of consistent behavior and properties of problem solving. Yet the subtle differences must not be overlooked. This is a time for both divergence and convergence of ideas.

The commonalities are not restricted to one category, but the following model tends to recognize how composites share features similar to how atoms within the same element may share electrons. This partially explains the interaction between the composites resulting in the individual's problem solving process. The distinctions between the composites allows for manageability when dealing with the attributes of the process. Without some form of contrast, the construct remains a fuzzy puddle of mixed up phenomena. With the composites, some control over the facets becomes possible. Further to this is the recognition that aspects of each of these composites lies both within, and outside, the solver's consciousness and control.

What follows is a description of each composite relative to the process. (See Figure One.)

Interaction of Composites and Their Influence upon Problem Solving



Influence:

+ positive

- negative

Ø neutral

The composites exert a positive, negative or neutral influence upon each other and upon problem solving.

The problem solving process in turn affects the composites in a continual and dynamic interplay.

Figure 1.0

J. Cameron, 1993

The Composites interacting with problem solving

The following structure of problem solving relates to the phases of learning (Biggs 1991) by recognizing the role of prior experience in developing the individual's attitude and skills. It shows how the context of a situation and the support perceived by the solver exert influence on the definition of a problem. The way an individual structures a problem draws upon the solver's skills and attitude. Problem solving interacts with all of these factors, creating a model from which to examine the process exhibited by students.

- **Attitude**

  This is how the individual views the task in relation to self. It generates or discourages ownership and commitment as whether or not "I want to ".

  Attitude incorporates the elements of motivation, whether or not the problem is real for the solver, and the climatic barriers the solver perceives as well as the intelligent behaviors of persistence, striving for accuracy and metacognition.

- **Past experience**

  This is the preparation, skills and abilities of the problem solver. It influences whether or not the problem solver perceives a successful outcome as possible and the problem solver's view of whether or not, "I can".

  This interacts with and incorporates the elements of metacognition, fluid and crystallized abilities, extrinsic and intrinsic problem solving style, intelligent behavior, adaptive and innovative style of creativity, problem solving skill and past experience, degree of novelty of the problem, as well as the behaviors of intelligence and good problem solving skill. The cumulative experience of an individual assists with developing the ability to predict consequences.

- **Environment**

  Environmental factors or context of the problem provide the circumstances for and consequences of the choices made by the problem solver. This influences the solver to ask, "What do I want?" and has a bearing upon how the problem solver defines the problem.

  Environment takes into account the motivational factors and consequences which also have influence on the attitude of the problem solver.

- **Support**

  The system that the problem solver *perceives* as available in terms of the knowledge, skills and assistance needed to complete the task successfully, addresses the question in the solver's mind, "What do I need to solve this?". It also has a bearing upon the problem solver's belief upon whether or not "I can".

  This includes the styles of teaching and leadership, types and numbers of sources of information, assistance and support available as perceived by the problem solver. The information necessary to solve the problem lies partially within this component.

- **Problem Type**

  The recognition, type, nature, structure and definition of the problem embedded in the task to be performed is often construed to be the deciding factor, yet it remains another of the crucial parts relative to the interaction of the whole. How each of these elements evokes the other composites becomes the situation the solver wishes to change.

A problem falls along a continuum of problem complexity. The awareness, experience and perspective of the problem solver greatly influences the problem solving strategy. What seems to be a new or difficult problem for one, may appear to be routine to, or may even be overlooked by, another. This also influences commitment and persistence.

A MODEL OF PROBLEM SOLVING

The solving of problems is the focus of human activity. It is the center of a universe of ideas, constructs, themes, conditions, stimuli and possible actions. Both interpersonal and intrapersonal, it is a human being's connection to the world. How one chooses to solve problems results from an interaction between wonder, uncertainty, experience, desire and mental activity. When an individual solves problems, he or she takes power over his or her life and may influence the lives of others. At the heart of the system is"Morris' (1966) description of *awareness of self*" (In Clark, 1979, p.100).

(a) self as a choosing agent unable to avoid choosing his or her way through life;
(b) self as a free agent, free to set the goals for his or her own life;
(c) self as a responsible agent, accountable for the choices made and how he or she lives those choices.

Unless individuals recognize their control over themselves and their control over problem solving, they do not see how people shape the world by the way they solve problems.

The five composites are like atoms. When they interact, they create the energy which forms molecules of problem solving, and become the building blocks of learning. This model is an attempt to describe the state of dynamic equilibrium between these elements. Depending upon the degree of force applied by one or more of the factors, the resulting influence will cause the system to stall, loop, spiral or restart. The key resides in the part/whole relationship between these entities and the manner in which the individual

problem solver manages and adapts to changing conditions. As the problem solving is occurring, it also exerts influence on the composites. In itself it reflects back and can change the attitude, skills, perception and need of support of the solver, affecting the environment and generation of subsequent problems.

It is critical to remember that these factors are neither *isolated* nor *static*. Rather, they are believed to be in continual interplay with each other and are dependent upon each other for the evolution of the problem solving process. The problem solver may enter this dynamic through any factor, and because of the interplay, each of the other factors will impact upon the problem solving process and may even cause it to be abandoned. The problem solver may also change his or her perception relating to a factor over time which will again alter the dynamic of the interplay.

Although elements of each factor are believed to be present in each problem solver's situation, the individuality with which the solver perceives and reacts to them is, in itself, the significant overall theme.

Each of these factors may be interpreted to have had either a positive, negative or neutral influence on each other. Problem solving is affected by, and in turn affects the composites and will be thus described as having impacted the decision making and subsequent flow of the individual's problem solving process.

Comparison of the Units

Five students, from the three problem solving units described in this study, will be examined in relation to their interaction with each of these composites and will be compared with the other units. Discussion will focus on what may be interpreted from the results of the unique interplay observed for the unit. Two of the units worked as individuals and the third worked as a team of three students.

All of the problem solving groups experienced aspects relating to *each* of the composites. This had a direct bearing upon the problem solving process exhibited. The most significant influence upon the process for all of the units, however, was the interaction between the solver's Attitude and perceptions relative to Support. The interaction was exaggerated or complemented by its interplay with Environment and Past Experience, and culminated in the definition and formulation of the Problem Type. This cumulative interaction evoked or diminished commitment and perseverance in solving the perceived problems. In a sense, the combination either escalated or diffused problems.

Attitude

This was found to be one of the most influential and reactive aspects of the process. Since involvement in the project was voluntary, it was assumed the students would match themselves to the opportunity. It was expected that the situational structure and context, interests, previous experience, abilities and nature of the participants would influence the process. Yet these seemed to manifest themselves as dominant and cumulative factors in the process itself, as evidenced through the attitudes and subsequent decisions of the students.

The first component of Attitude is the level of commitment the problem solver assigns to the task. This is formulated through motivation and a view of the task in relation to the self. The students could be classified by three categories of statements.

- Team One, Lise, Margaret and Wilma, exhibited an, "I can and I will" commitment.
- James is typified by "I'm not sure if I can and I don't want to".
- Anne is represented by, "I can and I want to".

Team One committed to the task early. They were enthusiastic to begin with and eager to do well. Their motivation might be considered Achievement, i.e. the desire to do well and feel good. Their enthusiasm waned when the problems occurred but they were committed to finishing the project and doing a good job. Their positive attitude was shaken by the internal support mechanism, usefulness of resources and materials, and by the way the

group interacted. Since they remained committed in spite of the negative effect of the other factors, their attitude is believed to have exerted a neutral influence.

James was initially drawn to the project by his belief that it was going to be a time for games. His attitude changed dramatically when the problem types became significant and his response to the support he perceived was not what he felt he needed. His motivation was seen to be Instrumental by reason of his definition of his real problem as one of avoiding the consequences he feared. He perceived he was in danger of receiving a failing grade so his attitude became a negative influence, destroying his commitment to the project.

Anne also displayed a dramatic shift in attitude. She did not volunteer to participate when she felt the task was just going to be another fill-in-the-blanks type of research project. When she heard the problem type being explained, it sparked within her a commitment that grew in intensity over time. Her motivation was seen to be intrinsic because she seemed genuinely interested in her results and desirous of further exploration.

The findings seem to suggest that when real world problems are dealt with through a classroom situation students benefit from a strong personal commitment. As well, time and all supporting personnel must be committed. These are ingredients for success and are critical in making the experience worth the time, resources and energy they require. Students need guidance and support through the process if they are going to maintain the commitment necessary to effectively address problems.

Treffinger and Isaksen's (1992) purposes for the second, or rehearsal, level in teaching problem solving show their value here. Once confidence, competence and commitment are established the student seems ready for the challenge of a real problem. Until that time, however, real problems can be very upsetting. That is not to say that real problems should never be approached until the personality, perseverance, effort, and community support are in place. Real problems will happen whether or not the solver is prepared for them, but

the smoothness of the solution process seems to be enhanced when those factors are present. Commitment is, in large part, what holds the process together.

Interestingly enough, the "FFlow" type of experience described by Michael Haynes tends also to describe the symptoms of good problem solving. Although none of the students described their experience as FFlow, to the eyes of the researcher, it appeared some were in a state of flow when they were moving forward through the problems. The pains of the frustration seemed to take a lesser toll on their energy and the excitement of success seemed to build commitment as they got nearer their goal.

An Alberta Alcohol and Drug Abuse Commission (AADAC) poster hanging on the school wall seemed to encapsulate the successful students' experience: "The ideal goal is one that seems too big at first, but grows smaller as you move toward it and becomes just the right size when you reach it."

Support

Support may take many forms. It can come as perception of assistance offered or desired, with leadership style being a part of that assistance. It also takes shape in the nature and amount of information the solver perceives himself to need in order to solve the problem as defined. Interaction with the support system seems to engender or dissipate attitude.

It would appear that, for this study, when the commitment was high, support might have been required, but seemed to have been structured more by the problem solver. With low commitment a greater degree of support seemed necessary.

Caution must be exerted though, in educators' matching support offered to the needs of the problem solver. Grow's (1991) work on teaching learners to be self-directed warned of the difficulties encountered with a near or severe mismatch of teaching style with student stage of self direction. Dependent learners were described as treating teachers "as experts who know what the student needs to do, or they passively slide through the educational system,

responding mainly to teachers who "make" them learn" (p.129). Self-directed learners were said to enjoy an atmosphere of autonomy. "The most severe problems occur when dependent learners are mismatched with non-directive teachers and when self-directed learners are mismatched with directive teachers"(ibid, p. 137).

All three units drew upon the support of the researcher and others but for different reasons and with different results.

- Team One wanted a mediator for their internal disputes and someone to grant permission to execute their ideas. They seemed to view the support as having had a positive influence on their problem solving process.

- James wanted the researcher to structure the class sessions and task for him. Although the nature of the task seemed to invite self-directed learners, James appeared to find a mismatch between the researcher's teaching style and his perceived needs. So support seemed to exert a negative influence on James' problem solving process.

- Anne, like Team One, wanted permission to go ahead with her ideas, but subsequently, she wanted a sounding board for her generalizations and hypotheses, as well as sources of additional information with which to verify her analysis. She seemed frustrated at times, but overall, her perception of the influence of the support was viewed as positive.

Sternberg (1985b) postulated that real problem solving often occurs in groups and it was evident through this study, that even if an individual was working on a problem alone, he or she often required a social context to facilitate thinking. A teacher phrased this as, " You have to do it by yourself, but you don't have to do it alone"(C. McLean, personal communication, November, 1992). Costa (1991) cited Vygotsky's (1987) points that "higher functions actually originate in interaction with others" (Costa, 1991, p. 12).

This draws attention to the usefulness of group problem solving as a mechanism for generating internal support. A group's membership usually consists of a variety of types thereby offering opportunity of access to each talent when needed. However, appreciation for differing styles and a willingness to communicate are prerequisite for the harmonious orchestration of talent. Myers, Slavin and Southern (1990, p. 260) supported this view but pointed out,

> that success with unstructured tasks requires the emergence of leaders who have the ability to help the group define a problem. This facility may be related to Getzels's (1982) characterization of the creative problem solver as a problem finder. In groups, this ability also seems to require input and collaboration from every member of the group. . . . This information provides implications for presenting and structuring group problem-solving experiences .

Myers et al. referred to Treffinger's earlier work and made the suggestion that "individuals often require educational intervention to develop independent learning skills. If this model is valid, it would also be possible to move students along an educational continuum in group problem solving"(p. 260).

Initially, Lise, from Team One, seemed to emerge as what Myers et al. (1990, p.259) termed an *authoritarian* leader as opposed to a *participative* leader. Authoritarians are characterized by attempts,

> to direct the group's output into channels amenable to their own ideas, often artificially constraining group decisions. Often they use . . . knowledge and verbal fluency to hold their position in the group's attention.

Lise seemed to fit the description of an authoritarian leader, because of the number of confrontational and resisting comments from Wilma and Margaret. Participative leaders are more willing to entertain ideas from the group. They are usually able to elicit and mould ideas to fit their own without the other members feeling as if their ideas have been modified.

Margaret seemed to fit the description of a *product/process leader* (Myers et al., 1990). These leaders were typified by students whose organizational skills focus on some specific segment of the product or process during a project. Since these leaders tend to emerge

later in a project in conjunction with the direction of a stronger authoritarian or participative leader, it seemed likely that Team One was effective because of the complementary relationship between these two leadership styles. The support they found within their group was strong, in spite of the personality clashes that accompanied it.

It seemed equally likely that the project, although successful, might have been more innovative had Lise been less dominant. Myers et al.(1990) suggested that in groups led by authoritarian types the projects were less creative. This seemed to be borne out by the conservative nature of Team One's project. Their work was strongly productive, but did not seem to break new ground.

There is some degree of irony in the relationship between leadership and creativity in James' case. Here, the leadership of the researcher served as an inadvertent negative influence. By trying to give James the chance to be creative, the researcher removed too many of the structures he relied upon. James perceived himself to be creative, but seemed to function best within bounds set by an authoritarian leader.

James demonstrated, through his conversation, the potential to be more creative with the research project than Team One, but lacked the necessary implementation skills and attitude that Team One presented. The researcher attempted to follow Myers et al.'s. (1990) suggestions to help bring out these abilities in James. Myers et al.(1990, p. 260) suggested that,

> When groups begin to flounder, a teacher could use task analysis to:
>
> (a) provide more structure to the task,
>
> (b) help the students define goals, or
>
> (c) provide preliminary leadership structure.

The researcher attempted to follow this guidance. In this project it was unsuccessful perhaps due, at least in part, to James' perception of leadership effectiveness. He defined authoritarian leadership as strong leadership, and found it difficult to adapt to participative leadership. It is possible that James might have confused the security and the simplicity

of both obedience and one-right-answer, with good leadership. He found it easier to do or not do as he was told. He was absolved of responsibility if the leader owned the control.

Another possibility removes confusion and assigns a different motive for James' interpretation of leadership. Wolfle (1991, p. 181) explored elements of expediency with which gifted students, particularly boys, approach their work.

> These predominantly male underachievers exhibit an attitude characterized by a desire to "do only enough to get by at a level adults will accept." The hypothesis is that this attitude begins early . . . . As early as kindergarten, gifted children are highly motivated to do the things they wish to do, and unmotivated to do what others think they should do. As a result they often learn to cope with their advanced understanding and curiosity by developing ways to pass the time that are creatively inattentive.

In light of his mother's comments about how the work was too easy for James when he "went through school" it begs the question of whether a gifted student can learn to outsmart himself in the game of *school*.

Mick, one of the other students not described, seemed to lend support to these possibilities. He openly admitted that he preferred to have assignments where the right answers were given because they made it easy to get his work over with, so he could get on to more interesting things. He described how he skillfully used questions to elicit cues from teachers as to exactly how they wanted him to perform. His strategy was to ask,"What do you think I should do?". Unfortunately for these students, post-educational experiences may require different skills.

Seeley's (1985) discussion of the constructs of fluid and crystallized intelligence seem to take on significance when observing the desired forms of support for the problem solving processes of these students. James did not seem to present evidence of fluid abilities when he sought structure, yet did seem to offer its potential through his ideas. This dichotomy raises further questions about whether his fluid abilities had been reinforced or perhaps even penalized in school, thus not likely to be selected by him for school assignments. This would possibly explain why he sought strong support for his project. However,

given the parameters and design of this study, there are too many other variables such as age, motivation and risk-taking to speculate much further. It would be generalizing beyond the data to suggest that this was, in fact, what happened with James in this instance.

To complicate matters further, the classroom teacher commented that the boys were also not above wasting their time for a while if they could. This confuses needs and wants and makes it difficult for a mediator to select an appropriate course of action. It was difficult to grant the time necessary for these students to grow when it seemed as if they were not trying to learn. Yet the researcher did not want to rush incubation time. Perhaps they did not even know when they needed a push and when they needed time to think and touch and play. Roger von Oech, (1983) stressed the need for two types of thinking during creative problem solving. *Soft* thinking is required early in a problem to allow the solver to play with ideas and manipulate variables, while *hard* thinking is needed later, to make practical applications and get the job done.

The researcher decided to offer assistance if, and when, requested because of the potential differences in learning styles, levels of novelty, maturity, and readiness factors. The researcher did not want to interfere with their process too much or too quickly by jumping in with a rescue they did not need nor want. The researcher was also unfamiliar with the students at the beginning and wanted to know them a bit more before deciding about how best to assist. Wolfle (1991) addressed the need for empathetic teachers intervening by structuring programming aimed at marrying students' interests with subject-matter as an avenue for developing interest and motivation. However, teachers need to be equally vigilant in expecting students to commit to their own learning. It becomes a team effort. In this study, the playing around with the game went on for many days until the researcher and the classroom teacher concurred that the boys were probably not taking the project seriously. At that point, the support deemed by the researcher to be necessary was to reaffirm the rules and let them try on their own to solve the problems they were creating. It raised the issue of the interaction of problem type and support through attitude, but in the time period and voluntary nature of this project, the parameters were not pushed.

As the project progressed the personalities of the students were starting to become more evident, and part of the researcher's task was to determine when and how to respond most appropriately to their individual needs and invitations for action. The researcher usually used questions to prompt thinking of their own solutions and was in frequent consultation with the teacher.

The researcher was intrigued with the embeddedness of the process, how one challenge would serve as a portal into a greater challenge. The researcher wrestled with the question of how much leading, and how much following the students' lead, should happen. If, in the name of support, the researcher had structured their problems for them, she would have robbed them of the opportunity to solve problems themselves. Yet, without some degree of structure for foundation many students could not build their own support. Some, especially James, had great difficulty with this nebulous stage and could not get past it toward a solution. Sternberg's (1985b) descriptions of everyday problems seemed to fit the observations made by the researcher when Sternberg pointed out that it is not always clear what information is needed to solve a problem, nor is it clear where to get the needed information.

Another of the most difficult aspects of providing assistance to these individuals was that they had to decide what kind of help they wanted before it could be provided. Like an editor, before the researcher could respond to the student's work, the student needed to have done something. But the irony for some became one of not being able to use the offer of help because they had not got started, and not knowing how to start until they got help. The students' plea was paradoxical, " Tell me what I should do, but don't tell me what to do".

Parents provided another source of support. Team One's parental support came in varied ways. It interfered when Wilma's father put stringent rules on her out-of-school activities,

including disbelief she was at the library doing background research. There was also assistance offered when Margaret's parents allowed computer access for report preparation.

James' parents often helped him with homework, and in some ways this seemed to engender some dependence on his part. He turned to his parents for help out of his problem and this time became even more frustrated because they would not let him quit.

Anne presented easy reliance upon support structures balanced with her strong independence. She was very comfortable with asking her father for statistical assistance and seeking other adults' advice as well, yet remained firmly in control of her project.

Significant too, was the researcher's personal and professional reaction to the discomfort experienced by these students as they became genuinely frustrated with the problems they were facing. It posed a variety of ethical dilemmas for the researcher. If the nature of a problem is to generate a challenge, then how does a researcher, parent or teacher, live with allowing the pain of the struggle? Rimm (S. Rimm, personal communication, 1989) suggested, "Steal their struggle and you steal their success", but the pain of the struggle is difficult for an observer to bear. These students were sensitive, still children, although they were rapidly approaching adulthood. They needed a delicate balance of guidance and independence. It was only through the project that James' traits and family dynamic surfaced. He, who had previously not experienced much struggle, found now, at grade nine, it was uncomfortable.

During the documentary, Common Miracles (ABC World News Tonight, 1992) the term, "controlled floundering" was used to describe the phase in the process whereby students failed initially at something that was interesting, but hard to do. Like the students shown on the program, all the students described in this study floundered, but ultimately succeeded, and learned a lot about learning in the process. Even James admitted to having been helped to learn a lot about himself and his approach to learning.

The researcher did not want to cause any undue harm or trauma to her subjects and yet to observe their problem solving they needed to work some problems through. The researcher hypothesized some discomfort could produce valuable growth. Juntune warned of this difficulty, "Thinking is hard work. Your students, when they hit the "wall," aren't going to say, "Oh, thank you. You are making me think" (J. Juntune, personal communication, 1987).

James felt overwhelmed, unhappy and trapped. He created some problems for himself that were much more real than he had counted on, and this slowed his assimilation of the learning of the rewards of the struggle. He did not welcome enlightenment about his habit of being rescued or structured, but he realized, and agreed later, that it was probably good for him to have encountered the difficulties he did.

Discussion with the classroom teacher confirmed this was not a unique episode but rather part of the trend of the manner in which he approaches much of his school work. However, the subsequent discussion with his parents where the pattern was explored and analyzed for cause and effect, was perhaps the more unusual experience, and it is to be hoped, the more constructive. Its usefulness could be measured by an increase in what Treffinger (D. Treffinger, personal communication, 1992) called "ownership" which he suggested is prerequisite to the commitment necessary to solve real problems.

Taylor (1974) reinforced this view by suggesting that teaching for test scores can deprive students of their chance to discover their own power. "If this pattern persists for repeated years of schooling, many of their potential talents may never be discovered and cultivated"(p.8). Perhaps James is somewhat a victim of his own learning. If he has interpreted schooling as reproducing knowledge he is missing the opportunity to construct it. He has passed the course but failed to understand it. The onus is also on his teachers to support him by not supporting him so much. Teachers should both have, and communicate, expectations which include creating knowledge as part of their message. In

the meantime the mismatch between a "dependent learner and a delegator" caused at least some of the problems for James to solve in this project (Grow, 1991).

The researcher believes that a person chooses whether to be successful or to be rescued. This choice however, is not always made consciously. It is the researcher's opinion that part of the teacher's job is to design opportunities for constructive and safe decision making, and to help students become aware of the choices they are making. Some of the theories, such as those of Dreikurs (1964), Coloroso (B. Coloroso, personal communication, 1985) and other investigators who are not really *behaviorists* but more like *managementists*, have suggested that adults should not own children's problems for them. That does not mean they should abandon children and leave them to solve problems completely by themselves, but mediate experience (Feuerstein, 1980). This helps them to metacognitively clarify what the alternatives are for their choices and assist them in predicting the possible outcomes of each. The solvers might also need help to accept that their control over consequences exists through the act of choosing. After a choice is made, consequences are no longer within their complete control. They become part of a cause-effect relationship spiral. James needed support recognizing and owning his control over the consequences of his inaction, instead of continuing to blame external factors.

This fits well with and supports Treffinger and Isaksen's (1992) concept of level two, practice problems. Treffinger and Isaksen stressed the need for this rehearsal and it appears the students agreed. James expressed some appreciation for the experience through his questionnaire. He commented he had learned something after the project was over and suggested that even though his experience had not been good overall, he thought real world problem solving might be an interesting part of the curriculum. Another

student-researcher, Diane, who also struggled with her project for a while, expressed similar sentiments almost poetically through her journal,

> We learned many lessons from this project, but most of them had nothing to do with Creativity. . . . We learned about how our minds worked, how to challenge ourselves, how to make use of our full individual potential, and many other skills we could never, ever learn from a book. I think that is the best teaching method of all— letting students teach themselves; . . . the tool is more useful than the product. . . thank you . . . for letting us fall on our tender faces to learn things (and this revelation) for ourselves.

The stages experienced by the subjects were similar to those of a young child attempting a new skill. The types of support and mediation offered by parents and teachers are similar in their intent. It is as though the students are advising teachers to, "Support only when needed, tolerate attempts, let go and celebrate accomplishment". These are aspects of success. Teachers and parents must let the students be responsible for their own learning, but be there when necessary. It is a delicate balance, difficult to strike and maintain through constant monitoring. It requires communication from both parties. Perceptiveness on the part of the coach and security on the part of the learner are vital ingredients of success.

It is the opinion of this researcher that the pendulum of school trend has swung too far toward overprotection of students. Concentration on removal and fear of failure in schools has ironically brought about a form of learned helplessness in some students. Educators seem to have forgotten the principle of weaning learners from their masters.

However, schools are not the only agency contributing to the development of children. Dependency is a characteristic fostered in the home as well. Sometimes schools can be pulled into the cycle of rescuing competent children by a well-intentioned effort to please a demanding public.

Responsibility is shared among many parties: the student, the home, peers, the school, community and society at large. The influence of these contribute to the physiological, intellectual, emotional, spiritual and social attitudes, views and actions of the problem

solver. In this study the students reflected varying degrees of need for support, and varying responses to the types of support offered. The effectiveness of the interaction with the support system seemed to determine the maintenance of attitudinal commitment.

School has, in some cases, become womb-like for students; and the transition process of meeting the real world can be an even more violent and regressive shock to the systems of children than the natural process of birthing itself. Real world problem solving can and should be rewarding for students who meet and conquer a struggle. With each conquest they gain a strengthened self-concept and a broadened approach to new problems. Schools should not miss the opportunity to design and welcome sample problems for solving that ignite student passion, challenge them to the fullest and relate to the outside world by bringing parts of it within school experiences. This way problems may be controlled, managed and discussed metacognitively. It conveys to students that they has the power to solve their own problems, which is possibly the best support that can be offered.

Past Experience

The assistance offered from previous problems and the confidence in his or her abilities that stems from it becomes part of the student's personal support base. The skills and abilities of the individual problem solver will also influence how the individual develops his or her attitude. Previous experiences will trigger responses to stimuli that might have a positive or negative effect on the problem solving process.

- Team One felt confident, because of their previous experience with research methods. They were able to effectively apply these skills to the new situation. Their past experience is viewed as having had a positive influence upon their problem solving process.

- James had a variety of experiences which seemed to negatively influence his interaction with the task. His own work habits and pattern of behavior, along with his family history prompted him to rely on support systems he perceived to be unavailable for this project.

- Anne's whole life seemed to have prepared her for the independent manner in which she approached this task, so it seemed her past influence was positive.

The classroom teacher expressed surprise that several students volunteered to become active participants even after reiteration that they could participate as subjects playing the game without having to commit to becoming researchers. Anne's willingness to take part in a research project reflected an uncharacteristic approach because she said she found science experiments and other research to be boring. This seemed to suggest the students might exhibit some surprising behavior throughout the process, but for the most part, the students behaved in characteristic fashion. The classroom teacher offered the explanation that students might have volunteered because they wanted to be part of the group. Team One and James also behaved consistently with their usual productivity patterns.

The way the students approached gaining entry to the project and responding to consequences provided an early clue about their personalities and the outcome of their problem solving process. The issue of returning permission slips promptly, demonstrated the initiative and responsibility levels of the participants. It correlated closely with the students who were able to quickly get on track solving the problems and those who struggled with organization and management, with the exception of James, who returned his slip without having read what he was getting into.

The students who had the most difficulty with this study seemed consistently to be those who had had little practice making choices or had seldom been allowed to face the consequences of the choices they had made. In these cases, it was reported by both the

teacher and parents themselves, there seemed to be a pattern in the child's life of parental protection and rescuing students from disappointing consequences.

Another of the patterns presented, and probably the most significant difference between the students, was the style of questioning they used. The questions varied in category, type and degree of depth. Anne asked questions about the possibilities of what her findings suggested. James asked what he should do. Team One's questions vacillated between procedures and refining practical problem statements, and what to do about the bickering.

The researcher felt the formulation of the students' questions was indicative of their habits. How much of this was due to personality and nature, and how much occurred as a result of personal history, parenting and school patterns, was difficult to determine. Nonetheless, the more independence of thought reflected in the question, the greater facility of problem solving was exhibited. Good question asking leads to good problem solving because questions help to formulate, or state, the problem. (Getzels, 1985). Nardi & Wales (1985, p. 220) supported this notion when they quoted Charles Kettering, "A problem well stated is a problem half solved".

The first time someone attempts to work on a problem alone, the results will probably be clumsy and awkward, but with practice and guidance they should improve. Anne's preparation for independence started at birth. Her personality and left-handedness precipitated the development and nurturing of her problem solving skills. James had a very loving family who were always there for help. He was an easy-going, compliant, happy boy who was secure within his family structure. It did not appear he had yet needed to strike out on his own to solve problems.

Anne and James both had a strong pattern of familial support. Both sets of parents were actively involved with their child's affairs. Both claimed their child was difficult to motivate on something he or she did not want to do, or was not interested in. Neither set of parents gave the impression they insisted the child participate in a task when the child

did not so wish. This leads to the question of how much of a student's problem solving style is a result of experience and how much is due to the child's nature.

It would have seemed logical to assume that since this was a group of students similarly identified as gifted for programming differentiation, having met eligibility criteria established by the school district, attending the same school in the same grade and class, they would likely have had similar experiences working on the same basic task. But although on the surface there appeared to be similarities in their experiences and basic structure of the process, each of the students had a different, and somewhat peculiar, experience based upon a variety of factors. Like siblings, each remained an individual whose orientation and preferences guided reactions and subsequent decisions.

Using Flexer's (1987) constructs of problem solving style, it would appear that James was more extrinsic while Anne was more intrinsic in their approach to problem solving. It also raises the question of whether or not style is evoked by additional factors. Team One seemed able to effectively employ elements of each style at different times. Lise, Margaret and Wilma definitely deferred to rules when approaching their research, yet were interested in the complexities of their data and readily invented their procedure. Their experiences seemed to indicate Team One shaped a more balanced and moderate view of which skills to employ and when to use them. Since they functioned as a group, they modified each other, so it was unclear as to the what the styles of the individuals might have presented.

Problem Type

The research task presented a variety of problem types for students to address. All students encountered two levels of a real problem through this study: one was an emotional problem, the other procedural. But the problems themselves were different for each unit.

- Team One took their research problem seriously, began to lose interest when they were underway, and looked for efficient, effective ways to persevere and do a good job. The procedural problems included being led astray by their survey results and having uncooperative middle-school subjects. Their emotional problems were

brought on by the mix of personalities attempting to work together. Their commitment to the task made the problems real to them. The influence of problem type seemed to be neutralized for this process.

- James had difficulty defining his research problem. He wanted to get out of the project without getting into trouble. His lack of an effective procedure and fear of the consequences contributed to his emotional frustration with having to deal with the problem. It was viewed as having had a negative influence upon his problem solving process.

- Anne wanted to make an important contribution through her research. She had to contain her enthusiasm within the parameters of the research project. She had to deal with the unravelling of issues and embedded problems unearthed through her investigation. She was frustrated she could not solve them all and needed to manage her data. She was also intrigued by the possibilities. Her problems were viewed as positive overall for the project.

Formulation

All were eager to get started immediately without much thought about research design. Then quickly they realized problems with not knowing where they were going or how to get there. They used questions to formulate their problems. The researcher offered assistance by using questions from the class as starting points for discussion about how to structure their investigations. Anne wanted to know, "How will you know . . . ?" The researcher used her question as a stimulus for the class. Students, together with the researcher, offered suggestions about generating questions to guide research, defining creativity, methods of proving what is observed and defining parameters for their investigations. Questions such as, "Can we leave the school grounds?", were indicative of the kinds of factors influencing data gathering, subject selection and initial problem definition.

Recognition

One of the most distinguishing features observed could probably be described as problem recognition. At first the group was excited and rambunctious but insisted orally they wanted to do the research. The written commitment consisted of submitting informed consent forms jointly signed with their parents. It raised a question about the validity of *informed consent.*. With reference to Bloom's (1956) taxonomy, the students may have known what the paper said, but the project's complexity may not have been completely understood. This could be interpreted as a *problem* with problem recognition and subsequent definition.

Perhaps the students did not realize the complexity due to their previous experiences with research. They were used to lots of structure, as Anne explained,

> In science the teacher already knows the answer and you just have to find it. It might take a week or two but you know it's there.

This project was not going to have predetermined answers but the students may not have fully realized that in the beginning. If they had recognized and understood to what degree they were structuring the research, and how difficult that might be because of the ill-structured nature of the problem, several might have opted out; with the exception of Anne, who was drawn to the opportunity because of its possibilities.

Metacognition has a crucial role in problem recognition. It includes the ability to notice when a chosen strategy is not working. Team One and Anne recognized their problems quickly, defined them readily and generated or elicited many alternatives before making a decisive choice of action. They were very conscious of predicting consequences of, and choosing, their decisions and were able to articulate their difficulties, ideas and plans.

The researcher could not conclusively state whether or not James looked for problems, but the evidence seemed to indicate he had difficulty perceiving them. It is speculation to suggest that, due to his inexperience with problem finding and formulation, that real problems, for the most part existed outside of James' perception at that time. James tended

to hang back and wait for problems to be brought to his attention, and when presented with a problem, seemed to look outside of himself for causes.

The findings of this study support Getzels (1985) and Kanevsky (1990) who stressed the important concept of problem finding, or understanding the problem. How well an individual puts the pieces together to define the actual problem, stripped of its camouflage, seems to directly influence the solution. Common sense would be to agree that the more clearly and accurately the problem is stated the better are its chances of being solved. Paradoxically, definition is probably the most difficult problem relating to problem solving. James, for example, was quite certain that his real problem was external and did not easily agree that there could be other facets of the problem under his control, which might be more the root of the problem than the tip he was identifying.

Treffinger and Isaksen (1992) placed much emphasis on Understanding the Problem, their first level of Creative Problem Solving (CPS). They indicated that the facilitated strategy of generating a fluent list of mess statements and facts about the problems, converted to problem statements and priorized to select a problem, would lead to understanding. To a certain degree that may be true, but when these students encountered real world problems, they were not all ready to go through such a formal process. Some were reluctant to address their real problems, even when invited to do so. To the knowledge of this researcher, the students had not been trained in the CPS procedures, so this cannot be considered conclusive evidence at this time.

After the project, during the pizza lunch, several students agreed that it had been a hard project for many of them. They admitted school is much easier when the answers are straightforward and the game of school is much easier to play when the rules are black and white. Two students described the leaps between problem solving levels one (skills), two (practice) and three (real problems) as a package deal, it must be able to be stretched but

still manageable. They too, supported the need for incremental steps between the stages. If the gap between the levels is too wide, they cannot make the jump.

Myers et al. (1990, p. 260) also suggested a switch in research emphasis from the leader to the task because the"nature of each task requires a new set of techniques, and each individual develops a unique style when confronting those task demands". Clearly, for James and Anne, the nature of the task had a profound effect upon both their attention and effort. But what appeared to be needed were the skills with which to cope with a variety of differing challenges.

Real problems

There was a marked contrast between those for whom the research problem was deemed *real*, and those who did not let the problem demand their personal involvement. There were the students who took their assignment seriously and approached it as such, and those for whom it was an opportunity for a different experience, not like regular schoolwork. As Mick, one of the other student researchers commented, "[It] seemed like fun, I thought I was getting out of an assignment".

Using Treffinger and Isaksen's (1992) definition of real problems as those that matter to the students and call them to action, it would appear that the real problem James was attempting to solve was how to avoid getting a poor grade with the least pain. The research project never seemed to become real for him but the discomfort associated with the perceived grading was. In this respect, he may have missed defining his research problem, but he was crystal clear in his articulation of his real problem relating to evaluation. Interestingly, his definition of the problem as being that of how to avoid getting a failing grade shaped his solution. Had he defined his problem as that of determining what he was doing that was causing him to deserve a failing grade, his processes for solution might have been very different. His process for solving the real problem, as he defined it, was to confide to his parents his disappointment and fear. That launched a familiar pattern of parental involvement and assistance with structuring a solution.

Structure

In general, the structure of the problems invited responses which could be classified into two main groups, those problems which were taken in stride and those which were viewed as insurmountable obstacles. The solver's perception of the degree of challenge presented by the problem evoked attitude, commitment and effort. Some of the students' reactions to these were more pronounced than others, and varied depending upon their definition of the problem. The variety of problems encountered posed a variety of structures for students to address.

These gifted students approached problems in different ways. Some might have had difficulties solving problems which posed no challenge for others. They did not all process information or respond to stimuli the same way. Anne found the open-endedness of the research problem invigorating, while James found it frustrating. Team One slugged through the procedures, chipping away at the list of jobs to be done while James attempted to keep the list to a minimum. The students all required differentiated programming to meet their individual needs for recognizing, defining and solving problems.

Problem solving and problem type

Generally, the strategies employed by most of the girls in the research group were fairly constructive. When they encountered problems, they were usually quick to recognize and identify them, fluent in the generation of alternatives, comfortable with the expression of frustration, flexible in examination of the problem from different perspectives and *movable* in that they sought and were open to assistance.

By contrast, the majority of the boys tended to have more difficulty pinpointing a problem, and missed recognizing some completely. They were usually wanting direction yet struggled with it. Questions in the form of "What should I do?" were often followed with statements of, "That wouldn't work . . ." after response from peers or the researcher. Then they usually engaged in a form of verbal rutting, sparring with each other about their

answers during the game, their intellectual ability, their research and their masculinity. This perhaps has a great deal to do with their age, but as Lipman (1986) affirmed, the plateau of reasoning is not really deviated from until college. If this is true, it raises questions about what might need to happen to improve reasoning ability later in life.

It did not appear that the students consciously saw themselves as determining to use, or actually employing, a specific process for problem definition. The Creative Problem Solving model was not specifically taught to the students as was done in the Crammond, Martin and Shaw (1990) research, but it was described and mentioned. Parnes' The Magic of Your Mind (1981) was also provided as reference material.

As the students went through the experience of their research and metacognitive reflection about the process, they seemed to change their understandings about research and some forms of problem solving in general. The process itself unfolded before their eyes. It became more clear and more complex. Issues were dealt with as they arose. The classroom teacher commented,

> This project has to have expanded the concept of research beyond science experiments and research essays for them.

The students had begun with an arm's-length, learned-it-at-school understanding of the general sequence of stages of a problem relating to the research process. But by working through and living with the sequence, they came to see it more as a labyrinth. They grew in understanding as they saw their roles change from being rule-followers to decision-makers. Instead of taking the travelled route the students learned to forge their own path through the research. They began to realize that research is never really over. Several commented that they had *done* lots of research projects in the past but this was the first time the answers were not already to be found somewhere in the book. Anne claimed she now understood why research costs so much and takes so long.

Not all welcomed this greater understanding. For Team One and Anne, it was the lure that drew them to persevere, for James it pushed him past his "comfort zone" (Tice & Kuhn,

1985) of the safe boundaries of school and assignments. It placed heavy demands on his tolerance for ambiguity. He seemed uncomfortable with or perhaps afraid of letting it become real and thus demanding commitment.

The size of the sample and problem solving process witnessed through this study revealed no easily generalizable conclusions but the evidence did seem to lend support to the theories postulated by other researchers in the field of problem solving. The most significant finding was that problem solving seemed to be directly related to the characteristics of the individual solving the problem. The way a particular individual recognized, formulated and defined the problem had critical bearing on the process of its solution.

Environment

The individual shapes the problem solving process, and the context shapes the individual. Just as past experiences affect the problem solver, so do the present ones. Although the environment for this project was the familiar setting of a school, many things were at work to influence the way in which the solver perceived his environment. However, for this project, it was not considered as major an influence as that of support, attitude or problem definition, but the subtle ways it shaped the process are not to be underestimated.

- Team One found the classroom environment safe for risk-taking and exploration of abilities. It was, however hostile within their group at times, especially with the surveys and when the middle-school group was acting out. The other two members blamed Lise for making the questions and picking the group. Even though they were getting tired and fed up with their work they would not let themselves quit. Overall, the influence of the climate was considered negative.

- James seemed to view the context as negative for a variety of reasons: his aversion to the New Age aspects of the game, the leadership style of the researcher, the attitudes of the boys with whom he was most closely associated and his perception of feeling trapped.

- Anne seemed to find herself able to shine with a community of inquirers. Other people seemed genuinely impressed and interested in her work. She was able to converse at an adult level with many people regarding her project, so the environmental influence was seen as positive.

The composite of environment lends support to another of Treffinger, Sortore & Cross' (1992) notions, that of the climate in which problem solving operates as an influence over the results of endeavour. They used the mnemonic device COCO to represent creative productivity as a function of the Characteristics of people, the Operations they perform in their Context leading to Outcomes. Increasingly through their work, they are finding support for the notion that this aspect is critical to the success of the problem solving process. Wolfle (1991, p. 183) summarized, "Children are born with the potential for advanced abilities, but it takes interaction with their environment to develop them".

There was a change in environment because of the researcher's presence and involvement. The researcher recognized this as an example of problem solving within a specific context, which may or may not be generalizable to other contexts. The purpose of this study had been to describe, not judge the problem solving process of the students. However, some form of evaluation became necessary to determine what was occurring during the phases, therefore enabling the researcher to attempt to distinguish among the participants and to respond to them appropriately. Efforts were made to avoid environmental bias by reporting and comparing the perspectives of the teacher, students, some parents and the researcher. Excitement, intensity, effort, productivity and metacognitive thinking, both introspective and about the problem, emerged as the researcher's criteria to gauge, thus describe, the effectiveness of the students' problem solving.

James appeared confused with the environment created by the surface structure of the project. His understanding of a more structured environment where he only had to repeat knowledge was what he perceived as work. He perceived being allowed to make his own decisions as an opportunity for getting out of work, but the demands of the research were

more rigorous than he expected. He did not accept the juxtaposition of creating knowledge within an open structure. Perhaps in James' opinion, the novelty of the learning environment created by the researcher was too much of a change for him to adapt in time for this project, but there were still similar expectations in his regular class. It is interesting to speculate that had James been presented with greater opportunities for self-directed learning previously, he might have responded differently to the demands of this project. Had this project offered the structure that James seemed to want, Anne would likely not have participated.

Problem Solving as a cumulative, interactive process

All of the composites previously described played an influential role in the evolution of the problem solving process observed by the researcher. Problem solving exerted its own influence as it spun the process along. It created the changed set of conditions inviting the solvers to re-examine their attitudes, recognize and structure the demands of emerging problems, determine the support they perceived was needed and draw from past experience or newly acquired skills within, and dependent upon, the context in which this dynamic process was occurring.

CONCLUSION

Balance is needed

The interaction of these five composites with problem solving seemed to be what comprised the observed process. Yet the theme of individuality was overriding. When educators provide opportunities for a balance of these factors, perhaps the solvers will be able to capitalize upon their strengths and build upon the strengths of others.

A system of this nature would support Treffinger and Isaksen's (1992) use of Kirton's (1976) descriptions of adaptive and innovative creativity, Flexer's (1987) constructs of extrinsic and intrinsic style, Seeley's (1985) view of fluid and crystallized abilities as well

as von Oech's (1983) hard and soft thinking. Rather than relying totally on any one part, a dynamic equilibrium of all of these is more effective with consideration being given to how each contributes to the whole. This places value on each, but emphasizes the element of timing. Using the analogy of a racecar driver changing gears depending upon the demands of the course, von Oech (1983) described the importance of recognizing changing conditions and knowing when to switch thinking style.

Knowing when to switch problem solving style is also important. James and Anne represented more extreme approaches to problem solving. James appeared to avoid problems without clear-cut solutions while Anne seemed to relish them and was blatantly bored when the element of autonomy was reduced. Although they each worked independently, support was continually available. Anne drew upon support frequently, while James felt he did not receive much. A person working alone is likely to be successful when that individual is comfortable with accessing help when needed. This reinforces the notion and value of group problem solving. Solving problems in groups is one way to achieve balance because each of the members brings a unique set of skills and talents upon which the group may draw.

This also supports Sternberg (1985b) when he observed that real world problem solving often occurs in groups. He suggested though, that there is a problem with that very notion. Some of the most influential problem solvers, even world leaders, have become successes in their own rights through individual efforts, while the skills of collaborating with others to solve problems is new and perhaps foreign to them. It is nonetheless a vital skill to develop. Gifted students are "at risk for greatness" (Robinson, 1981) and perhaps one of the factors contributing to this is that they are not automatically good problem solvers. Another is that perhaps they do not always know how to solve problems in groups.

Self Reflection

Good problem solving, whether in groups or as individuals, includes reflecting upon the effectiveness of the process and decisions made. Evaluation is an essential tool in both

creative and critical thinking. Its role is appreciated by researchers and practitioners alike. Moreover, evaluation is crucial for effective metacognition in students, because it links past, present and future learning. Often students' reflective journals have lots of writing, but limited self-evaluative reflection. Teachers must model self-reflection if they wish it to be valued, developed and practised by students.

It follows then, that this researcher practise the very skills she advocates. This research study needs to be evaluated. Like the gifted children being studied, any research method has its strengths and limitations, each has a great deal to offer and a great deal to learn from others. The wholistic research methodology selected and designed for this study had, as expected, its share of both advantages and disadvantages.

The design itself was intended, for the purposes of this study, to be a compromise between what the researcher saw to be a counterproductive dichotomy between qualitative and quantitative research. Her intent was to blend some elements of each *without compromising* the integrity of either the data or the study. She did so at a risk of clashing paradigms, because different aspects of methodology were more appropriate for one or the other camp. The essence of each brand of research is often communicated through terminology defining the nature of its aspects. However, the researcher believed that the concepts behind some of these words transcend language to fit people. For example, rigor, although spawned from quantitative research, could be adapted to mean carefulness, and avoidance of narrowness of thought. Paul, Binker, Martin, Vetrano, and Kreklau (1989 p. 3-4) use the term *fairmindedness* to describe the type of thinking the researcher attempted to emulate in her design, implementation and data interpretation of this study.

> The other perspective, however strange it seems to me now, may have something both important and true, which I have overlooked and without which my understanding is incomplete. Thinking along these lines, I open my mind to the possibility of change of perspective. I make sure that I don't subtly ignore or dismiss these new ideas; I realize I can make my point of view richer, so it encompasses more. As I think within another perspective, I begin to see ways in which it is right. It points out complicating factors I had previously ignored; makes useful distinctions I had missed; offers plausible interpretations of events I had never considered; and so on. I become able to move between various perspectives, hence freed from the limitations of my own thought.

> One of the most important stages in my development as a thinker, then, is a clear recognition that I have a perspective, one that I must work on and change as I learn and grow. To do this, I can't be inflexibly attached to any particular beliefs. I strive for a consistent "big picture." I approach other perspectives differently. I ask how I can reconcile the points of view. I see variations between similar but different perspectives. I use principles and insights flexibly and do not approach analysis as a mechanical, "step one, step two" process. I pursue new ideas in depth, trying to understand the perspectives from which they come. I am willing to say, "This view sounds new and different; I don't yet understand it. There's more to this idea than I realized; I can't just dismiss it.
>
> Or, looked at another way, suppose I'm rethinking my stand on an issue. I re-examine my evidence. Yet, I cannot evaluate my evidence for its completeness, unless I consider evidence cited by those who disagree with me. I find I can discover my basic assumptions by considering alternative assumptions, alternative perspectives. I use fairmindedness to clarify, enhance, and improve my perspective.

This researcher honors and respects all dimensions of research methodology, but found neither qualitative nor quantitative approaches to be fully satisfactory for the multiple purposes for this study. She found the dichotomy between the camps of investigators to be getting in the way of what she wanted to do, and what she felt important for helping students. Each method "tells you something, but it does not tell you everything" (J. Mielnichuk, personal communication, 1987), and educators cannot afford to throw away significant data just because it is inadequate in isolation.

At the risk of intruding upon a classroom of learners, the researcher introduced a connection to real world problem solving, an opportunity which might otherwise not have been possible. This move could be seen by some to have violated the ecosystem of the learning environment in purist qualitative methodology. By contrast, opening up the list of variables while not going far enough in her design development, and not experimenting or comparing the student researchers with the control group of their peers, with such a small sample of students, the researcher traded off the possibility of gathering hard evidence of the problem solving exhibited by students or proving her interpretations valid. These decisions raise the questions of, "What, if anything, was the researcher able to find through her inquiry?" and "How valid are her conclusions?".

In spite of the problematic elements associated with an unusual research design, when the opportunity arose to conduct the project, the researcher believed its many facets had qualities which made the study worth attempting. Evidence from many varied sources was likely to be illuminating. Certainly there would always be imperfections in the structure of a design, but even the most valuable of emeralds have flaws. Brilliant-cut gems sparkle because of their many facets complementing each other. A lackluster performance is so because it has too few facets. The potential for growth was present, but the researcher knew there were risks. As George Bernard Shaw suggested, "The people who get on in this world are the people who get up and look for the circumstances they want, and, if they can't find them, make them" (Sproul, 1956, p. 362) so the researcher invented a design to match the intent of her study. The researcher attempted to include enough factual observations and richness of perspective to support her interpretations. Although she believes in the value of her findings, she discovered that there were blind spots and rough edges along the way.

The researcher re-learned, as all teachers know, how difficult it is to design activities which meet students on many levels and allow them to grow at their own rate. It was challenging to remember to include all the theories to which she subscribed while busily involved with students on a daily basis. It forced the researcher to examine the uncomfortable possibilities that some part of the students' progress depended upon the limits of her own personality, expertise and knowledge; thus success or difficulty was a shared responsibility. The paradox of this realization was both a gift and a burden, not unlike student talent, potential and practice.

The responsibility for leaving the security of more traditional research methodology was not without growing pains. Occasionally, involvement in the study made the researcher feel like Stephen Leacock's Lord Ronald who, "flung himself from the room, flung himself upon his horse and rode madly off in all directions" (Sproul, 1956, p. 213). Each facet and participant seemed to be entangled in a process difficult to record and describe while in motion. As it was with the student researchers, even though this researcher found the

work intriguing, trying to pull the pieces together was draining. Bringing structure to the broad topic was difficult. Having too many choices can be as frustrating as having too few. However, sometimes a person learns more about all that he or she is when that individual is doing something unfamiliar. Like the sum of the atomic spins, the different parts do not even know themselves until brought together in a specific context. Teachers and researchers, like parents, do the best job they can at the time, learn from it and move on.

The structuring of the questionnaires was intended to assist both the students and the researcher in moving forward. They were designed so that they would help students to focus and reflect upon their learning, in the hopes the debriefing would help them to leave the project better than they found it. The researcher was also looking for another source of perspective to triangulate interpretation of the data from her observations.

Like Team One, the researcher found some of her survey questions to be more fruitful than others. The short-answer questions on the first page of the questionnaire seemed to evoke most of the students' voice. The responses to the subsequent questions, although more clearly marked, were more obscure in their meaning thus more difficult to interpret. Although the researcher invited the students to elaborate their responses, the rating-type of questions on pages three and four were often just assigned a number or symbol without further explanation. Mere tabulation of the results did not offer the researcher enough depth for confidence in her analysis of the data from these sources. They raised too many concerns about the clarity, nature and construction of the questions; formatting of the layout; complexity of the multiple levels for response and student fatigue by the fourth page. However, they still seemed to corroborate the findings from the observations to a fair degree, with a few surprises, such as James' perception of assistance.

The regularity of both consistency of, and surprises from, observations seems to be the natural order of investigations of any sort. In meteorology, large air masses behave with amazing consistency, yet on an immediate level weather can be incredibly changeable.

Even supersaturated water vapour remains a cloud until a nucleus of matter is present. A microscopic speck is all that is needed for precipitation to form. Although observing, talking to students or interviewing them are good ways of getting to know what they value; too much distance and introspection remain an abstract cloud in students' minds when it comes to describing how values drive their problem solving process. Without a context in which to operate, talking about themselves is often too nebulous for students. Researchers need to give students a large enough speck of content to precipitate problem solving. Talking about what matters to them enables to students describe the "*it-depends-on ...*" facets of their behavior, or clarify in what light one is seeing *stuff*. A balance between process and content is necessary. That is why the school setting was such a useful place to gather information about students. Educators must marry curriculum to students to produce the everyday act of learning. It is through a range of activities that a teacher begins to see the whole student, and can then attempt appropriate programming for that individual. The activity in which a student is engaged shapes the flow of his or her behavior.

As well, trying on for size the unique situation a teacher experiences allowed the researcher different insights that may not come from hearing and watching. This is not to imply that there is nothing to be gained from another type of approach, only that its limitations might also be considered. Similarly, the catalyst for the problem solving observed in this situation was limited by the unique context. The design of the study prevented the researcher from accurately measuring or generalizing the impact of the factors on these students.

Any lens can enhance or blur vision. Being aware of the lenses through which their conclusions are viewed forces researchers to consider other perspectives. The researcher recognizes and accepts the limitations and strengths of this exploration into student problem solving. She believes that the interpretation of the students' problem solving processes provides an avenue to more questions. Based on the understandings gleaned from this study, a new question arises: *What next? What does this description of the students'*

problem solving process do to assist teachers, parents and the students themselves in solving real problems?

The composite model of problem solving interaction synthesized for this study enabled the researcher to view problem solving in a multi-dimensional fashion. Previous outlines of the process had seemed somewhat flat. The researcher agreed with the general stages listed in the literature on problem solving and had instructed her students in the steps. However, the familiarity of the sequence was somehow not enough to enable students to self-activate the cycle or to use the stages to bring structure to an ill-structured problem. The researcher found students needed further assistance and was confused why the process seemed inadequate. There seemed to be more to the process than the tip the list of stages allowed the researcher to see. The composite model developed here helps explain what lies beneath the surface and why the process stages are indeed adequate to view the iceberg. The model helps the teacher to analyze other influencing facets and to understand what causes the sub-problems that seemed to bog down the students' progress. It offers teachers a way of assessing the students' process and predict what needs to come next in programming.

Students in schools have diverse characteristics and are constantly changing. The model seemed to help the researcher to capture a portion of this dynamic, and hold it long enough to differentiate between the subtle and interlocking elements underlying student performance. This understanding offers another lens through which to analyze problem solving situations. The new scope allows the researcher to hypothesize possible causes for successes and difficulties while assisting with nurturing metacognition and self-evaluation in students. By determining what factors are present, missing, strong or in need of remedy; teachers can develop programming and learning opportunities to enhance problem solving in students. It allows educators to predict, prepare for and respond to the daily weather of an individual student's problem solving, having used the model to study the long-term *climate* of his or her problem solving process. This type of sensitive, reflective teaching and learning does not have to rely too heavily upon sophisticated technology and complex statistical analysis. After all, Eratosthenes, some 2300 years ago,

was struck by a puzzling question. He surmized the world was round after defining his research problem and determining a process for verifying his observations. He went on to accurately calculate the circumference of the planet using simple tools, mathematics and good thinking (Anno, 1979).

Research is a form of communication. It provides a window through which individuals with different perspectives may come to view and understand each other. It is an opportunity for growth. This researcher, through her life's experiences which include: travelling and sampling different cultures; exploring habitats above the earth as a pilot, and below the sea as a scuba diver; studying philosophy, science, languages, art and literature; working with and teaching individuals ranging in age from first-grade to graduate studies and parenting two small children has developed a sense of her own perspective. She considers herself a citizen of a planet teaming with diversity, and has come to believe that the value of research is its unique opportunity for people to find resonant chords through living with or reading the results of each other's work. Therefore she feels all research needs to reflect the researcher's efforts to recognize his or her own view and search for other explanations, respecting those which need translation or are beyond his or her present perceptual boundaries. Isadora Duncan is credited with saying, "If I could tell you in words, I wouldn't have to dance".

An old adage, "a person cannot drink from the same river twice", reinforces the concept of intellectual growth from changing contexts as well as perspectives, while recognizing that every learning opportunity is linked to its moment in time. So it is with this study of human problem solving behavior. It was through this particular research project that Team One's, James' and Anne's traits surfaced as they did. A series of experiments, observations or interviews might, or might not, have been able to capture their real world problem solving behavior. It remains a judgement call on the part of the researcher whether or not it was wise to have attempted this study in the manner chosen. The researcher recognizes additional questions and arguments about whether or not the students were gifted, if they were or were not receiving differentiated programming that might have

prepared them for problem solving, or whether her interpretations were valid or biased. There are no guarantees that the problems faced by the students were real to them, relevant to their learning or even appropriate to meet their needs as learners. However, being fairminded in considering these alternative perspectives allows the researcher to clarify and enhance, thus strengthen her perspective.

For these reasons the researcher believes the market research project question served its purpose here. Another question may or may not have been any more useful. It is doubtful any ill-structured problem is more suitable for the students than their regular work until they structure their own definitions for it. This evokes the interplay of the model and was what made for the interpretations the researcher made at this time. This approach does not preclude future investigations into more facets of the problem solving processes, but by then this experience will become part of the past, and all involved will have moved on to a new attitude, influenced by a new context. The problems and support perceived then will impact upon the future process and the dynamic will continue to spin.

A researcher does not know till he or she is in the study what will be found. To embark upon any exploration carries a risk. Research is a hard-to-achieve balance between preparation and predisposition, but explorers feel the need to try, and cannot succeed alone. A summary of this self evaluation is reflected in the words of Elliot Eisner, "this is the best of me right now" (E. Eisner, personal communication, April, 1991).

Implications for teaching and learning

The results of this study indicate real world problem solving is both needed and possible within the context of school. However, for it to be appropriate, it must be carefully designed, with sufficient flexibility in it to meet a wide range of needs, then monitored and adapted for each individual. Finally, there must be support by administrators, teachers, parents and students.

In spite of the difficulties and complexities, there was enough evidence of student support to recommend real world problem solving be included in students' school experience.

Evidence also seemed to suggest that the more often students try to solve manageable problems, and the sooner in their educational careers they commence with, and maintain, emphasis on process training, the better they develop skills of coping with the challenges real problems pose. Treffinger (D. Treffinger, personal communication, December, 1992) strongly supported this notion, but recognized that often instruction in the problem solving process falls short of the mark.

Merely suggesting modification of instruction is not enough. There needs to be support for teachers wishing to change and invitations (Purkey, 1970) for those who do not yet sense the need. Currently, there are abundant materials for working on level one skills and level two practice problems. Treffinger and Isaksen (1992) and Renzulli (1977) emphasized insisting students move past these two levels and allowing students to make the transition to real problems. However, the many instructional conditions suggested in the literature are at risk of being ignored, left out or misapplied in busy, burdened classrooms. Glaser said, "we have always known what makes good thinking <u>if</u> we did it . . ."(ASCD video, 1986). Part of the findings of this study is the reinforcement of how important it is that teachers *do* take the time and energy to let students struggle with problems. How else will they acquire the practice they need?

Beyer (ASCD video, 1986) also supported this notion when he cautioned against filling the students' day with meaningless stuff. He suggested that educators are confused as to what is essential for students to learn, and are doing too many of the wrong things. Biemiller and Meichenbaum (1992) suggested that learners need to leave some "surplus mental capacity" during tasks so that they would be able to think while working. An example of this occurs when novice skiers are attempting to catch up to their friends farther down the slopes. The novice is going beyond his or her capabilities, and too quickly, in order to meet with the others who have had the time to pause for a rest before the lagger arrives. Once the beginner gets close, the experts are off again, once more putting the slower one in a position of not being able to stop or improve skills in the rush to gain ground. The more gifted skiers must also be encouraged to focus on refining technique and to continually set

new challenges for themselves. Pacing appropriate to the individual is important and time must be made available for metacognition. Tasks must be matched to the learner, so skills are thoroughly acquired, meaningful and cumulative.

Mancall, Lodish and Springer (1992) suggest that the use of databases will assist students in structuring problems and acquiring necessary information skillfully when adequately trained to utilize the technology currently available.

SUMMARY

The observed process of problem solving used by student-researchers in this study, was consistent with the stages described in the literature. (Feldhusen, Van Tassel-Baska & Seeley, 1989; Parnes, 1981; Treffinger & Isaksen,1992). Essentially the problem solving process observed followed the same general steps formulated by Polya (1957). There seemed to have been four phases. However the degree and effectiveness to which these were experienced differed depending upon how they were approached and treated by the participants in the working groups. The four general phases of the process were:

- Familiarizing self with elements of research and topics,
- Determining a course of action by structuring the problem(s) through framing questions and establishing parameters,
- Implementing the decisions, monitoring and modifying as required, and
- Effecting closure.

The length of time spent in each phase differed depending upon the extent to which it was developed. Sometimes a phase was experienced more than once. Like Bloom's (1956) taxonomy, the process phases appeared at first to be hierarchical and sequential, but the researcher's observations found them to be neither linear nor discreet. Rather they were recursive and cumulative, each possessing different levels of complexity. The problem solver built upon previous experience and influenced the next phase through the direction the learner consciously or subconsciously chose to take, relative to the solver's attitudinal response and the support perceived to be needed and available. The problem types

perceived by the students varied. Anne and James kept returning to their questions, trying to redefine their research problem. Team One would get over a disagreement and plunge headlong into another, having to start their negotiations and communication process all over again.

The researcher speculated whether the fragmentation of the timetable in the school environment was another contributing factor to the length of time it took to get progress occurring. Because gifted students often become fixated on a project of interest, the fifty-minute periods did not always seem to contribute to maintenance of sustained and concentrated effort. By contrast, for those not using the time wisely, it is questionable if increased time would have proven beneficial.

The overall dynamic of the project seemed to resemble a propeller as it slowly overcomes inertia. A lot of energy was expended at the beginning, but the motion was slow. There were many parts to get going in the students' projects, but gradually the pace increased until things started moving along by their own momentum.

The process was like the flow of a stream over rocks— fluid and moving, yet at times turbulent and circular. Problem solving became the whole greater than the sum of its parts. Its parts consisted of the research project itself, the process as it evolved through the problems it posed, influences on individuals, and the students' patterns of diagnosis and treatment of problems. The continuum of problem solving grew with the types of problems encountered by the solvers, their use of past experience, responses to support within the environment of the project and their attitudes, in reaction to the interrelationships of the five composites. Interrelated with the research but also reflective of other aspects of the students' lives, these attributes exemplified elements of a process in motion. A Chinese saying summarized, "Learning is like rowing upstream; not to advance is to drop back" (Day & Geistfeld, 1984)

The problems, past experiences and environment all influenced the solvers' problem

solving, but the two critical elements underlying the phases which seemed to have had the greatest bearing on decision making, problem solving effectiveness, and feeling of success or failure with the project, were the individual solver's attitude and response to assistance.

Participants varied greatly in their reactions and responses to these elements. Initially, and on the surface, the differences were generally distinguished by gender in that the male and female students appeared to have accepted the assignment and approached the problems differently. These general differences from the onset tended to break down into more personality-specific reactions as the project evolved. Gifted students are often referred to collectively. However it quickly became evident that this was a group of individuals, each approaching a similar task from a unique perspective. Each valued and reacted to the process differently.

The individual participants approached the problems posed by this project, in a fashion similar to the pattern with which they approached problems in school generally, but some aspects of their process seemed exaggerated by the structure of this particular assignment.

The students' reactions produced a variety of behaviors which in turn created differences in the experiences of success or difficulty. These included how they got started, persevered through problems and managed the project. As time passed, some got better, some got worse, some did not progress significantly.

Some aspects of attitude, support and past experience seemed to predetermine valuing of the project and reaction to phases. These included the students' history of, and opportunities for, independence to take ownership and responsibility for decision making. It was also reflected in the students' process training in the skills of organization, management, problem solving, research and interpersonal communication. The school's and family's patterns of rescuing the student influenced the student's perception of support. Educators and parents must be careful not to over- or underestimate gifted students' abilities in being able to cope with the challenges problems present.

These students need to be viewed as competent, but growing individuals. Open communication and choices must be part of the environment if they are to take risks and accept challenges and make wise use of available resources. A student's clarity of purpose depends upon how he or she defines problems and decides upon a course of action. This stems from his or her attitude toward school and the project's demands. Attitude is the student's personality and sense of self. It results from the knowledge of his or her abilities, sense of security, maturity, tolerance for ambiguity, initiative and ability to give and take direction. It transforms into commitment, willingness to persevere and ability to work with others on problems.

Recommendations for further research

The findings of this study have raised several other questions pertaining to understanding student problem solving of real world problems. The following recommendations for further research are discussed in two main categories, rather than by specific questions.

The first area of research would be to link with other disciplines and go more deeply into the intricacies of student functioning. With the current brain research uncovering physiological differences in learners, as well as socialization and modelling issues there are many unanswered questions regarding how to nurture thinking, learning and problem solving in all students, so their individual gifts might be evoked. Investigators could assess students' problem solving behavior relative to the composite model, with emphasis on ill-structured problem types. Development of an instrument to determine the effects of each composite on motivation, learning or problem solving ability might lead to curriculum development for facilitating student growth. In this way, personal history and family dynamics could also be investigated to assist parents with mediating experience before students enter school.

Further research into the interaction of fluid and crystallized intelligence, with adaptive and innovative creativity, and extrinsic and intrinsic style through process training, might offer

insight into the affective components of motivation, risk-taking, leadership and problem solving. As well, explorations in to the natural learning of students complements the information researchers can gather about them, for it illustrates how the parts function in a whole system.

The other area of concern to this researcher, is how to make use of the findings of existing studies. Teachers have always tried to utilize recommendations from researchers, but it often difficult for them to put theories into practice. A particular strategy may emerge from research and appeal to educators. It may then be adopted with great fervour, but might sometimes lack depth. The reasons behind selecting a strategy need to be understood, so the practice remains true to its theoretical underpinnings. As well, there are many facets of learning which should be synchronized in order to provide an optimum learning environment.

Teaching materials which are theoretically well organized are likely to produce the kinds of results today's public demands. A few teachers, such as Fritz and Holdsworth, are able to go beyond the needs of a single class. They have been designing sophisticated materials which systematically develop students' thinking and problem solving abilities within the context of developing the "basic skills" students' need (L. Fritz, and B. Holdsworth, personal communication, 1992). Continuing the work of teachers such as these who are able to synthesize several theories and unite them with practice should be encouraged and expanded because they offer springboards from which other teachers may leap.

As well, development needs to be coordinated with assessment. Evaluation measures need to be created and tested through research to prove the desired results are being achieved. This type of development should include process training and sample problems leading to working with ill-structured problems. Empirical studies within this area could pursue which teaching methods and teacher behaviors enhance student thinking. Although the skills of teaching for transfer are documented (Costa, 1991; Crammond, Martin, & Shaw, 1990; Perkins, & Salomon, 1988; Treffinger & Isaksen, 1992), there needs to be further

work on how to support more teachers in their attempts to adopt the suggestions made by researchers.

Researchers need to be investigating patterns which influence motivation through family, school and social interactions. There is need to investigate ways of coordinating these systems. Facilitating teachers' efforts to pursue applying process training and teaching for transfer is a task much more complex than it might seem, for there are many facets to learning. Teaching is more than giving out information. It needs to function within the context of a community. One of the ways these studies could be approached, might be through a layered series of steps. Generating materials to assist teachers in setting up programs following the move toward dealing with real problems, such as Treffinger and Isaksen's (1992) three stage model of thinking skills and problem solving; comes first. Then using these materials with students leads to measuring the results of working with them.

Teachers also need assistance with developing learning opportunities which allow for individual differences in readiness and skill in owning and solving real problems of varying degrees of structure. As well materials need to be created to help parents set the stage for students to develop in all their learning environments. Cultivating autonomous learners who will be successful in dealing with the increasingly complex issues and problems of today and tomorrow's society is a many faceted, exciting and challenging ill-structured problem. Learners are anxiously awaiting discovery or invention of a structure in the search for its solution.

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APPENDIX ONE

PROJECT QUESTIONNAIRE

Name:

1. Describe any frustrations you encountered during this process.

2. What were the problems you identified as a result of the frustrations you sensed during this experience?

3. What were the alternatives you thought of?

4. What help did you receive? From what/whom?

5. What did you choose to do about the problems?

6. Briefly compare your experience to Sternberg's descriptions of "Real World Problems". (See attached summary.) What similarities do you notice? What, if any, real world problems did this experience pose for you?

7. In what ways might this experience have helped you deal with real world problems?

8. Would you recommend situations like this be included in "regular" school experiences, why or why not?

Factors to consider when teaching for transfer of Problem-Solving and Thinking Skills:

In the everyday world, the first and sometimes most difficult step in problem solving is the recognition that a problem exists.

In everyday problem solving, it is often harder to figure out just what the problem is than to figure out how to solve it.

Everyday problems tend to be ill-structured.

In everyday problem solving, it is not usually clear just what information will be needed to solve a given problem, nor is it always clear where the requisite information can be found.

The solutions to everyday problems depend on and interact with the contexts in which the problems are presented.

Everyday problems generally have no one right solution, and even the criteria for what constitutes a best solution are often not clear.

The solutions of everyday problems depend at least as much on informal knowledge as on formal knowledge.

Solutions to important everyday problems have consequences that matter.

Everyday problem solving often occurs in groups.

Everyday problems can be complicated, messy, and stubbornly persistent.

Sternberg, R. J. (1985). Teaching critical thinking part 1: Are we making critical mistakes? Phi Delta Kappan, 67, 194-198.

Describe and rate the usefulness of the following:

	Very Useful	Quite	Somewhat	Slightly	Hardly
1. Teacher's comments to whole class	5	4	3	2	1
2. Teacher's comments to yourself	5	4	3	2	1
3. Teacher's comments to a fellow researcher	5	4	3	2	1
4. Prior knowledge about research procedures	5	4	3	2	1
5. Prior knowledge about problem solving	5	4	3	2	1
6. Prior knowledge about other...	5	4	3	2	1
7. Self selected resources	5	4	3	2	1
8. Resources provided by teacher	5	4	3	2	1
9. Peer comments	5	4	3	2	1
10. Peer procedures	5	4	3	2	1
11. Peer findings	5	4	3	2	1
12. Other sources...	5	4	3	2	1

For each of the following, please assign ratings in answer to all these questions. Please elaborate or explain if you feel comfortable doing so.

I Rate the following emotions and sensations you may have experienced during this process.

II At which stage of the process did you feel that way? (May be >1)

III Was this enjoyable?

IV How important is it to feel this way?

I Most of Time (5) Often (4) Sometimes (3) Seldom (2) Hardly at all (1) Didn't Notice (0) Don't Understand Word (U)

II Before (A) Early On (B) During Middle (C) Near End (D) After (E)

III Yes (Y) Lots (L) Slightly (S) No (N)

IV Very (+) Somewhat (0) Little (>)

Sensations

-_____ this is fun
-_____ it's new to me
-_____ it's different
-_____ it's a challenge
-_____ I'm doing real market research
-_____ it's exciting to _____
-_____ I get to make my own decisions
-_____ I'm getting out of another assignment
-_____ I get to work with my friends
-_____ I get to solve problems
-_____ I'm having to think
-_____ I'm learning something_____
-_____ it's important to _____
-_____ I'm making new knowledge for others
-_____ I feel successful
-_____ I'm proud of my work
-_____ I'm getting the help I need_____
-_____ I'm glad I'm doing this
-_____ I am doing well
-_____ I'm pleased with my progress _____
-_____ I'm conquering my problems_____
-_____ I'm reassured by _____
-_____ I'm taking risks _____
-_____ Other feelings/reasons:
_____
_____
_____

-_____ I want to bail out because_____
-_____ it's too hard
-_____ I'm getting tired of it
-_____ I've got too much else to do
-_____ I'm stuck
-_____ it's too complex
-_____ I'm not doing as well as I'd like
-_____ it takes too long
-_____ I keep having to start over
-_____ I'm having trouble with_____
-_____ I'm overwhelmed
-_____ it's too much work
-_____ I expected something easier
-_____ there's too much to learn
-_____ the expectations aren't clear
-_____ the answers aren't clear
-_____ there's a lot to learn
-_____ I'm glad it's over
-_____ I need more help from_____
-_____ I'm confused by_____
-_____ I want to know more_____
-_____ I'm puzzled by _____
-_____ I'm annoyed at _____
-_____ It's _____ fault that _____
_____
_____
_____

Thank you very much for your participation in the project, and for your time spent answering these questions.